JP2006503481
PUB DATE: 2006-01-26
APPLICANT: QUALCOMM Incorporated

HAS ATTACHED HERETO CORRESPONDING ENGLISH LANGUAGE EQUIVALENT:

US20030124976
PUB DATE: 2003-07-03
APPLICANT: TAMAKI TSUYOSHI, ; SAKAI KATSUMI, (+2)

WIRELESS LOCAL AREA NETWORK REPEATER WITH AUTOMATIC GAIN CONTROL FOR EXTENDING NETWORK COVERAGE

Publication number: JP2006503481 (T)

Publication date: 2006-01-26

Inventor(s):

Applicant(s): QUALCOMM Incorporated

Classification:

- international: H04B7/15; H04L12/28; H04L12/56; H04W88/04; H04W84/12

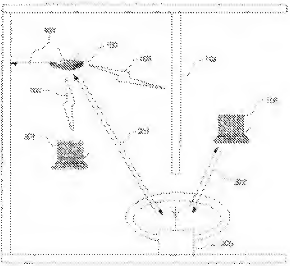
- European: H04B7/155B; H04L12/28W; H04L12/56B; H04W88/04

Application number: JP20040544751T 20031015

Priority number(s): US20020418288P 20021015; WO2003US29130 20031015

Abstract not available for JP 2006503481 (T)
Abstract of corresponding document: WO 2004036789 (A1)

A frequency translating repeater (200) for use in a time division duplex radio protocol communications system includes an automatic gain control feature. Specifically, a received signal (330) is split to provide signal detection paths (331, 332) wherein detection is performed by amplifiers (301, 302) filters (311, 312), converters (313, 314) and a processor (315). Delay is added using analog circuits such as SAW filters (307, 308, 309, 310) and gain adjustment provided by gain control elements (303, 304, 305, 306).



(19)日本国特許庁(JP)　(12)公表特許公報(A)　(11)特許出願公表番号
特表2006-503481
(P2006-503481A)
(43)公表日 平成18年1月26日(2006.1.26)

(51)Int.Cl.		F I		テーマコード（参考）
H04B 7/15	**(2006.01)**	H04B 7/15	Z	5K072

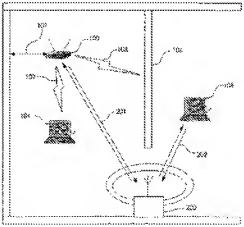
審査請求 未請求　予備審査請求 有　（全 15 頁）

(21)出願番号	特願2004-544751 (P2004-544751)	(71)出願人	504468448 ワイデファイ インコーポレイテッド WIDEFI, INC. アメリカ合衆国 32901 フロリダ州 メルボルン スイート 1012 ゲートウェイ ドライブ 1333
(86)(22)出願日	平成15年10月15日 (2003.10.15)	(74)代理人	100068755 弁理士 恩田 博宣
(85)翻訳文提出日	平成17年4月11日 (2005.4.11)	(74)代理人	100105957 弁理士 恩田 誠
(86)国際出願番号	PCT/US2003/029130	(72)発明者	ゲイニー、ケネス エム、 アメリカ合衆国 32901 フロリダ州 メルボルン スイート 1012 ゲートウェイ ドライブ 1333 ワイデファイ インコーポレイテッド
(87)国際公開番号	WO2004/036789		
(87)国際公開日	平成16年4月29日 (2004.4.29)		
(31)優先権主張番号	60/418,288		
(32)優先日	平成14年10月15日 (2002.10.15)		
(33)優先権主張国	米国 (US)		

最終頁に続く

(54)【発明の名称】ネットワーク・カバレージを拡張するための自動利得制御を備えた無線ローカルエリア・ネットワークの中継器

(57)【要約】
時分割二重無線プロトコル通信システムに使用される周波数変換中継器（２００）は、自動利得制御機能を備えている。詳細には、信号検出経路（３３１、３３２）を提供するために受信信号（３３０）が分割され、検出は、アンプ（３０１、３０２）、フィルタ（３１１、３１２）、コンバータ（３１３、３１４）及びプロセッサ（３１５）により行なわれる。ＳＡＷフィルタ（３０７、３０８、３０９、３１０）を始めとするアナログ回路を使用して遅延が加えられ、利得調整は利得制御要素（３０３、３０４、３０５、３０６）により与えられる。



【特許請求の範囲】
【請求項１】
時分割二重（ＴＤＤ）無線プロトコルシステムに使用される周波数変換中継器であって、
周波数変換中継器に関連する２つの周波数チャネルのうちの１つに信号が存在するか否かを検出するように構成された検出器回路；
前記信号に関連する周波数チャネルを前記２つの周波数チャネルのうちの一方から前記２つの周波数チャネルのうちの他方に変更するように構成された周波数変換器；及び
信号検出間隔及び送信機構成間隔を補償すべく、信号に遅延を付加するように構成された遅延回路；
を備えた周波数変換中継器。
【請求項２】
前記遅延回路はアナログ記憶装置を有する、請求項１に記載の周波数変換中継器。
【請求項３】
前記遅延回路は、アナログ信号記憶及びチャネル選択のうちの１又は複数に対して構成された少なくとも１つの表面弾性波フィルタを有する、請求項１に記載の周波数変換中継器。
【請求項４】
前記検出器回路はプロセッサを有する、請求項１に記載の周波数変換中継器。
【請求項５】
前記検出器回路はアナログ検出器をさらに有する、請求項４に記載の周波数変換中継器。
【請求項６】
利得制御回路をさらに有し、該利得制御回路はそれに関連する利得値及び減衰値のうちの１つを備えている、請求項１に記載の周波数変換中継器。
【請求項７】
前記検出器は、信号の受信信号強度をさらに検出するためのものであり、前記利得制御回路は、信号の利得値を調整するために該信号の受信信号強度をさらに使用するためのものである、請求項６に記載の周波数変換中継器。
【請求項８】
前記利得制御回路は、特定の信号送信出力電力を達成するために、所定の基準に基づいて前記利得値及び前記減衰値のうちの少なくとも１つをさらに制御するためのものである、請求項７に記載の周波数変換中継器。
【請求項９】
前記所定の基準は、特定の信号送信出力電力を修正するためのものであり、受信周波数と送信周波数の間の周波数分離、取締規則、温度、受信電力レベル、送信電力レベル、及び検出された干渉レベルのうちの少なくとも１つを含んでいる、請求項８に記載の周波数変換中継器。
【請求項１０】
プロセッサはさらにメモリを有し、前記所定の基準が該メモリに格納される、請求項８に記載の周波数変換中継器。
【請求項１１】
時分割二重（ＴＤＤ）無線プロトコルシステムに使用される周波数変換中継器であって、
周波数変換中継器に関連する２つの周波数チャネルのうちの１つに信号が存在するか否かを検出し、かつ信号の受信検出信号電力を検出するように構成された検出器回路；
前記信号に関連する周波数チャネルを２つの周波数チャネルのうちの一方から２つの周波数チャネルのうちの他方に変更するように構成された周波数変換器；
信号検出間隔及び送信機構成間隔を補償すべく、信号に遅延を付加するように構成された遅延回路；及び

前記検出器回路によって検出された受信検出信号電力に少なくとも一部基づいて、信号の利得値を調整するように構成された利得制御回路；
を備えた周波数変換中継器。
【請求項１２】
前記利得制御回路は、２つの周波数チャネルのうちのどちらの一方で信号が受信され、２つの周波数チャネルのうちのどちらの他方に変更されるかを含む基準に少なくとも一部基づいて、利得値を調整するように構成されている、請求項１１に記載の周波数変換中継器。
【請求項１３】
前記基準が、送信のための取締規則、動作温度、及び受信周波数と送信周波数の間の周波数分離のうちの少なくとも1つをさらに含んでいる、請求項１２に記載の周波数変換中継器。
【請求項１４】
前記基準が、受信周波数と送信周波数の間の距離をさらに含み、前記自動利得制御回路は、該距離に基づいて信号に対してよりフィルタ処理を適用するようにさらに構成されている、請求項１１に記載の周波数変換中継器。
【請求項１５】
時分割二重（ＴＤＤ）無線プロトコルシステムに使用される周波数変換中継器であって、
周波数変換中継器に関連する２つの周波数チャネルのうちの１つに信号が存在するか否かを検出するように構成された検出器回路；
前記信号を無線周波数（ＲＥ）信号から中間周波数（ＩＦ）信号に変換するように構成された周波数変換機；
前記ＩＦ信号に関連する周波数チャネルを２つの周波数チャネルのうちの一方から２つの周波数チャネルのうちの他方に変更するように構成された周波数変換器；
信号検出間隔及び送信機構成間隔を補償すべく、前記ＩＦ信号に遅延を付加するように構成された遅延回路；及び
前記ＩＦ信号の利得値を調整するように構成された利得制御回路；
を備えた周波数変換中継器。
【請求項１６】
前記利得制御回路が、検出器回路によって検出された受信検出信号電力に少なくとも一部基づいて、ＩＦ信号の利得値を調整するようにさらに構成されている、請求項１５に記載の周波数変換中継器。
【請求項１７】
前記検出器回路及び前記利得制御回路は、第１の信号経路と第２の信号経路にそれぞれ位置する、請求項１５に記載の周波数変換中継器。
【請求項１８】
前記検出器回路は対数増幅器を有し、該対数増幅器の出力は該出力を制御するために利得制御回路に結合されている、請求項１７に記載の周波数変換中継器。
【請求項１９】
前記検出器回路及び前記自動利得制御回路は各々異なる帯域幅を有している、請求項１８に記載の周波数変換中継器。
【請求項２０】
前記自動利得制御回路はプロセッサと、所定の基準を格納するメモリとを有し、プロセッサはＩＦ信号のオフセット利得値を確立するために前記所定の基準を使用するように構成されており、検出器回路によって検出される信号の検出受信電力とは無関係に、送信機の目標出力電力が少なくとも一部生じる、請求項１９に記載の周波数変換中継器。
【請求項２１】
前記プロセッサは、
対数増幅器の出力をデジタル信号に変換し；かつ

該デジタル信号を使用してＩＦ信号の利得値を確立する；ようにさらに構成されている、請求項２０に記載の周波数変換中継器。
【請求項２２】
時分割二重（ＴＤＤ）無線プロトコルシステムに使用される周波数変換中継器における周波数変換の方法であって、
周波数変換中継器に関連する２つの周波数チャネルのうちの１つに信号が存在するか否かを検出すること；
前記信号に関連する周波数チャネルを２つの周波数チャネルのうちの一方から２つの周波数チャネルのうちの他方に変更すること；及び
信号検出間隔及び送信機構成間隔に等しく、信号に遅延を付加すること；
から成る方法。
【請求項２３】
前記遅延を付加することは、アナログ記憶装置の信号を遅延させることを含む、請求項２２に記載の方法。
【請求項２４】
前記遅延を付加することは、アナログ信号記憶及びチャネル選択のうちの１又は複数に対して構成された少なくとも１つの表面弾性波フィルタの信号を遅延させることを含む、請求項２２に記載の方法。
【請求項２５】
前記検出することは、アナログ検出器において検出することを含む、請求項２４に記載の方法。
【請求項２６】
前記信号に関連する利得を設定することをさらに含む、請求項２１に記載の方法。
【請求項２７】
前記利得を設定することは、前記所定の基準に少なくとも一部基づいて利得を設定することをさらに含む、請求項２６に記載の方法。
【請求項２８】
前記所定の基準は、受信周波数と送信周波数の間の距離、取締規則、温度、受信電力レベル、送信電力レベル、及び検出された干渉レベルのうちの少なくとも１つを含んでいる、請求項２７に記載の方法。
【請求項２９】
前記所定の基準をメモリに格納することをさらに含む、請求項２８に記載の方法。
【請求項３０】
時分割二重（ＴＤＤ）無線プロトコルシステムに使用される周波数変換中継器における周波数変換の方法であって、
周波数変換中継器に関連する２つの周波数チャネルのうちの１つに信号が存在するか否かを検出すること；
前記信号に関連する周波数チャネルを２つの周波数チャネルのうちの一方から２つの周波数チャネルのうちの他方に変更すること；
信号検出間隔及び送信機形状間隔を補償すべく、信号に遅延を付加すること；及び
前記信号の検出受信電力レベルに少なくとも一部基づいて、信号の利得値を調整すること；
から成る方法。
【請求項３１】
前記利得値を調整することは、２つの周波数チャネルのうちのどちらの一方で信号が受信され、２つの周波数チャネルのうちのどちらの他方に変更されるかを含む基準に基づいている、請求項３０に記載の方法。
【請求項３２】
前記基準は、送信のための取締規則をさらに含む、請求項３０に記載の方法。
【請求項３３】

前記基準は、受信周波数と送信周波数の間の周波数分離をさらに含む、請求項３１に記載の方法。

【請求項３４】

時分割二重（ＴＤＤ）無線プロトコルシステムに使用される周波数変換中継器における周波数変換の方法であって、

周波数変換中継器に関連する２つの周波数チャネルのうちの１つに信号が存在するか否かを検出し、存在する場合に、信号の受信電力レベルを検出すること；

前記信号を無線周波数（ＲＦ）信号から中間周波数（ＩＦ）信号に変換すること；

前記ＩＦ信号に関連する周波数チャネルを２つの周波数チャネルのうちの一方から２つの周波数チャネルのうちの他方に変更すること；

信号検出間隔及び送信機構成間隔を補償すべく、前記ＩＦ信号に遅延を付加すること；及び

前記信号の検出受信電力レベルに少なくとも一部基づいて、前記ＩＦ信号の利得値を調整すること；

から成る方法。

【請求項３５】

前記検出と前記調整が、第１の信号経路と第２の信号経路でそれぞれ行なわれる、請求項３４に記載の方法。

【請求項３６】

前記検出が、前記信号から対数信号を生成し、該対数信号を前記調整のために使用することを含む、請求項３５に記載の方法。

【請求項３７】

前記調整が、所定の基準を使用して、前記ＩＦ信号の利得値を調整することをさらに含む、請求項３６に記載の方法。

【請求項３８】

前記生成は、対数信号をデジタル信号に変換することをさらに含み、前記調整は、該デジタル信号を使用してＩＦ信号の利得値をさらに調整することを含む、請求項１９に記載の方法。

【請求項３９】

時分割二重通信システムに使用される周波数変換中継器であって、

少なくとも第１の周波数チャネルと第２の周波数チャネルで送信を受け取ることが可能な少なくとも２つの受信機；

前記第１の周波数チャネルで送信することが可能な少なくとも１つの送信機；

第２の周波数チャネルで送信することが可能な少なくとも１つの送信機；

周波数変換中継器に関連する２つの周波数チャネルのうちの１つに信号が存在するか否かを検出し、かつ信号の受信電力レベルを検出するように構成された検出器回路；

前記信号に関連する周波数チャネルを前記第１及び第２の周波数チャネルのうちの最初のチャネルから前記第１及び第２の周波数チャネルのうちの次のチャネルに変更するように構成された周波数変換器；及び

マイクロプロセッサに格納された所定のパラメータに基づいて第１及び第２の周波数チャネルを構成することが可能なマイクロプロセッサ；

を備え、

第１及び第２の周波数チャネルの少なくとも１つに対する特定周波数の構成は、前記所定のパラメータに基づいており、

前記所定のパラメータは、取締送信機パワー制限、取締帯域外放射制限、及び第１周波数チャネルと第２周波数チャネル間の周波数分離、の少なくとも１つを含んでいる、周波数変換中継器。

【発明の詳細な説明】

【技術分野】

【０００１】

（発明の属する技術分野）

本発明は、一般に、無線ローカルエリア・ネットワーク（ＷＬＡＮ）に関し、詳細には、自動利得制御（ＡＧＣ）を使用してＷＬＡＮ中継器に関連するカバレージ・エリアを拡張することに関する。

（関連出願の相互参照）

本願は２００２年１０月１５日に出願された米国仮出願出願番号第６０／４１８，２８８号に関連し、その優先権を主張すると共に、発明の名称が「無線ローカルエリア・ネットワークの中継器（WIRELESS LOCAL AREA NETWORK REPEATER）」であるＰＣＴ出願第ＰＣＴ／ＵＳ０３／１６２０８号にさらに関連する。いずれの出願も参照により本願に組み込まれるものとする。

【背景技術】

【０００２】

通称ＷＬＡＮと呼ばれている、無線ローカルエリアネットワークのための幾つかの標準プロトコルが普及しつつある。これらは、（８０２．１１無線標準規格に記載されている）８０２．１１、ホームＲＦ，及びＢｌｕｅｔｏｏｔｈ等のプロトコルを含む。現在に至るまでに市場で最も成功を収めている標準無線プロトコルは、８０２．１１ｂプロトコルであるが、８０２．１１ｇ等の次世代プロトコルもまた普及しつつある。

【０００３】

通常、上記標準無線プロトコルを利用する製品の仕様は、例えば１１ＭＢＰＳ程度のデータレートと、例えば１００メートル程度の範囲とを示すが、これらの性能レベルは、実現されるとしてもごく稀である。実際の性能レベルと特定の性能レベルとの間の性能不足には、ＲＦ信号の放射経路の減衰を始めとする、多くの原因がある。ＲＦ信号は、８０２．１１ｂの場合、屋内環境等の動作環境では、２．４ＧＨｚの範囲である。アクセスポイントからクライアントまでの範囲は、一般に、一般家庭で要求されるカバレージ範囲より小さく、わずか１０乃至１５メートルであり得る。更に、ランチ式の家や二階建ての家のような分離した間取りを有する構造物、又は、ＲＦ信号を減衰し得る材料で構成された構造物では、無線カバレージが必要とされる領域は、例えば、８０２．１１プロトコルベースシステムの範囲外の距離だけ、物理的に離間され得る。減衰の問題は、他の２．４ＧＨｚ装置からの干渉や帯域内エネルギーに関する広帯域干渉を始めとする動作帯域での干渉が存在すると悪化することがある。また更に、上記の標準無線プロトコルを用いて動作する装置のデータレートは、信号強度に依存する。カバレージ・エリアの距離が大きくなるにつれて、通常、無線システムの性能は低下する。最後に、プロトコル自体の構造が動作範囲に影響を及ぼす可能性もある。

【０００４】

中継器は、通常、無線システムの範囲を大きくするために移動無線業界で用いられている。しかしながら、任意の装置におけるシステムの受信機や送信機は、例えば、８０２．１１ＷＬＡＮ又は８０２．１６ＷＭＡＮ無線プロトコルを利用するＷＬＡＮでは、同じ周波数で動作し得るという点で、問題と厄介な課題が生じる。このようなシステムでは、中継器の動作時にそうであるように、多数の送信機が同時に動作する場合に、障害が発生する。通常のＷＬＡＮプロトコルは、明確に定義された受信時間と送信時間を与えず、また従って、個々の無線ネットワーク・ノードからのランダム・パケットは、自発的に生成・送信され、時間的に予測可能でないため、パケット衝突が発生し得る。このような障害に対処する何らかの対応策が存在し、それには例えば、２つ以上のノードがパケットを同時に送信することを回避するために使用される、衝突回避プロトコル及びランダム・バックオフ・プロトコルが挙げられる。８０２．１１標準プロトコルの下では、例えば、衝突回避のために分散調整機能（distributed coordination function,ＤＣＦ）が使用され得る。

【０００５】

このような動作は、送信帯域と送信帯域が二重周波数オフセット分だけ離間されているＩＳ－１３６、ＩＳ－９５又はＩＳ－２０００標準規格に基づくシステムを始めとする他

の多くのセルラ式中継器システムの動作とは大幅に異なっている。周波数分割二重（ＦＤＤ）動作では、受信機及び送信機チャネルが、アップリンク及びダウンリンク双方に対して同じ周波数上にある状況で発生するような、中継器動作に関連する衝突が存在しないため、中継器の動作が簡素化される。

【０００６】

他のセルラ式移動システムは、送受信チャネルを周波数ではなく時間によって分離し、更には、特定のアップリンク／ダウンリンク送信のためにスケジュール化された時間を利用する。このような動作は、通常、時分割二重（ＴＤＤ）と呼ばれる。これらのシステムのための中継器はより簡単に構築されるが、これは、送受信時間が公知であり、また、基地局によって一斉送信されるためである。これらのシステムの受信機及び送信機は、物理的分離、アンテナ・パターン、又は偏波分離を含む、いかなる数の手段によっても分離され得る。これらのシステムの場合でさえ、中継器のコスト及び複雑さは、一斉送信される既知のタイミング情報を提供しないことによって大幅に低減することができ、従って、より経済的に実現可能な中継器が可能になる。

【０００７】

従って、同じ周波数で動作するＷＬＡＮ中継器は、上記の自発的な送信能力のために固有の制約を有し、従って、固有の解決策を必要とする。これらの中継器は、送受信チャネルに対して同じ周波数を用いるため、何らかの形態の分離が中継器の送受信チャネル間に存在しなければならない。例えば、無線電話に用いられるＣＤＭＡシステムを始めとする幾つかの関連システムは、指向性アンテナ、送受信アンテナの物理的分離等の高度な手法を用いて、チャネルの分離を実現しているが、このような手法は、複雑なハードウェアや長いケーブル配線が好ましくない家庭を始めとする多くの動作環境では、ＷＬＡＮ中継器にとっては現実的でなく、あるいは、コスト高になることがある。

【０００８】

国際出願第ＰＣＴ／ＵＳ０３／１６２０８号に記載され、また、本願と同一の出願人が所有する、あるシステムは、周波数検出及び周波数変換方法を用いて受信チャネルと送信チャネルを分離する中継器を提供することによって、上記に挙げた課題の多くを解決する。上記出願に記載されているＷＬＡＮ中継器は、第１周波数チャネルのある装置に関連するパケットを、第２の装置によって用いられる第２周波数チャネルに変換することによって、２つのＷＬＡＮユニットの通信を可能にする。変換に関連する方向（例えば第１チャネルに関連する周波数から第２チャネルに関連する周波数への方向、又は第２チャネルから第１チャネルへの方向）は、中継器とＷＬＡＮ環境のリアルタイムの構成に依存する。ＷＬＡＮ中継器は、送信のために双方のチャネルを監視し、また、送信が検出されると、第１周波数の受信信号を他のチャネルに変換するように構成され得る。この場合、信号は第２周波数で送信される。

【０００９】

上述の解決方法は、パケット送信に応答して監視及び変換をすることにより、上述した分離の問題と自発的な送信の問題の両方を解決し、また更に、小規模で廉価なユニットで実現し得る。しかしながら、ＷＬＡＮ中継器は、法律を遵守するために、例えばＦＣＣ（連邦通信委員会）等により発布されている出力とスペクトルの制約条件内で送信を行わなければならない。しかしながら、多様な電力レベルを有することがあり、これは干渉等により引き起こされる途絶や信号再送信の失敗や最適状態に及ばない状態に寄与する要因に対する精度の高い補償を必要とするという点で、問題が生じる。

（発明の概要）

従って、様々な例示の及び他の実施形態において、本発明は、ＷＬＡＮ環境等の無線環境において、また、大まかに言えば、ＩＥＥＥ８０２．１６、ＩＥＥＥ８０２．２０及びＴＤＳ－ＣＤＭＡを含む任意の時分割二重システムにおいて、動的周波数検出方法を用いて、カバレージ・エリアを拡張する。例示のＷＬＡＮ周波数変換中継器は、２つのＷＬＡＮノード又はユニットが、一方の装置によって用いられる第１周波数チャネルから他方の装置によって用いられる第２周波数チャネルへパケットを変換することによって、通信を

行うことを可能にする。チャネル１からチャネル２への変換の方向は、チャネル２からチャネル１への変換に対して、リアルタイム構成に依存する。中継器は、好適には、送信のために双方のチャネルを監視でき、また、１つのチャネルで送信が検出された場合、中継器は、受信信号を他のチャネルへ変換し、そこで受信信号が送信されるように構成される。

【００１０】

好ましい実施形態では、受信信号は、第１の信号経路で検出され、利得は第２の信号経路に適用される。さらに、利得信号経路は、信号検出と利得設定が、信号が再送信される前に起こるのを許容すべく、好ましくは遅延回路を備えている。利得は、受信電力レベルとは無関係に一定である目標送信電力レベルを達成するために、検出された受信電力レベルに基づいて設定される。しかしながら、目標電力は、１又は複数の以下のものを含む基準に基づいてまず決定又は調整され得る：受信周波数と送信周波数の間の分離、取締規則遵守、温度、受信電力レベル、送信電力レベル、及び検出された干渉。較正表を含むソフトウェアを備えたマイクロプロセッサは、目標出力電力を固定する適切な利得設定値の計算を行なうのに適している。本発明の詳細は、以下に続く図面の説明で詳しく説明する。

【００１１】

好ましいアプローチは分離の問題を解決し、小規模で廉価なユニットを許容すると共に、送信をモニタしそれに応答する際の自発的な送信の問題も解決し、送信機における出力電力を一定にする。この出力電力は、マイクロプロセッサにより決定される中継器の構成に依存して、異なってもよい。

【発明を実施するための最良の形態】

【００１２】

ここで図１を参照すると、広域接続１０１が、無線ゲートウエイ又はアクセス・ポイント（ＡＰ）１００に接続され得る。広域接続１０１は、例えば、イーサネット接続、Ｔ１回線、広帯域無線接続又はデータ通信経路を提供する任意の他の電気的接続であってよい。無線ゲートウェイ１００は、クライアントユニット１０４，１０５に、ＩＥＥＥ８０２．１１パケット又はＢｌｕｅｔｏｏｔｈ、Ｈｙｐｅｒｌａｎ、又は他の無線通信プロトコルに基づく信号を始めとする、ＲＦ信号を送る。クライアント・ユニット１０４，１０５は、パーソナルコンピュータ、携帯情報端末、又は、上述した無線プロトコルの１つを介して他の同様な装置と通信し得る任意の他の装置であってよい。各クライアントユニット１０４，１０５へのそれぞれの伝播経路すなわちＲＦ経路は、符号１０２，１０３で示す。

【００１３】

ＲＦ経路１０２を搬送される信号は、クライアントユニット１０４と無線ゲートウェイ１００との間の高速データパケット通信を維持するのに充分な強度を有するが、ＲＦ経路１０３を搬送され、クライアントユニット１０５に向けられる信号は、壁１０６又は１０７等の障害構造物を通過して、ある位置へ至る場合には減衰され、その位置では、無線中継器２００への方向でなければ、あるとしてもほんの少しのデータパケットしかどの方向にも受け取られない。無線中継器２００の構成と動作については次に説明する。

【００１４】

クライアントユニット１０５までカバレージ及び／又は通信データレートを強化するために、無線中継器２００は、無線ゲートウェイ１００から第１周波数チャネル２０１で送信されたパケットを受信する。無線中継器２００は、通常、例えば、約６．３５ｃｍ×約８．８９ｃｍ×約１．２７ｃｍ（２．５インチ×３．５インチ×０．５インチ）の寸法を有する筐体に収納でき、好適には、標準の電気の差込口に差し込んでＡＣ１１０Ｖ電源で動作可能である。無線中継器２００は、第１周波数チャネル２０１のパケットの存在を検出し、そのパケットを受信し、より大きな電力を用いてそのパケットを第２周波数チャネル２０２で再送信する。従来のＷＬＡＮ動作プロトコルとは異なり、無線ゲートウェイ１００が第１周波数チャネルで動作しても、クライアントユニット１０５は第２周波数チャネルで動作する。戻りパケット動作を実行するために、無線中継器２００は、第２周波数

チャネル２０２でクライアントユニット１０５から送信されたパケットの存在を検出し、そのパケットを第２周波数チャネル２０２で受信し、そのパケットを第１周波数チャネル２０１で再送信する。次に、無線ゲートウェイ１００は、パケットを第１周波数チャネル２０１で受信する。このように、無線中継器２００は、信号を同時に送受することが可能であると共に、無線ゲートウェイ１００のカバレージ及び性能をクライアントユニット１０５まで拡張することが可能である。

【００１５】

上述した様な混信によって生ずる問題や混信のある経路に沿う信号強度の付随的減衰に対処して、クライアントユニット１０５までカバレージ及び／又は通信データレートを強化する場合、図１に示すように、例示の無線中継器２００を用いて、例えば周波数変換を介して、伝播経路制約条件によって制限される範囲を超えてパケットを再送信し得る。ＡＰ１００から第１周波数チャネル２０１で送信されるパケットは、中継器２００で受信され、好適には、より大きな電力レベルで第２周波数チャネル２０２で再送信される。クライアントユニット１０５は、好適には、あたかもＡＰ１００も第２周波数チャネル２０２で動作しているかのように、第２周波数チャネル２０２で動作し、例えば、周波数変換がトランスペアレントでありＡＰ１００が実際には第１周波数チャネル２０１で動作していることを知らない。戻りパケット動作を実行するために、中継器ユニット２００は、第２周波数チャネル２０２でクライアントユニット１０５から送信された戻りパケットの存在を検出し、好適には、第２周波数チャネル２０２でパケットを受信するように、また、例えば、第１周波数チャネル２０１でＡＰ１００にデータパケットを再送信するように構成される。

【００１６】

無線中継器２００は、好適には、２つの異なる周波数、例えば第１周波数チャネル２０１及び第２周波数チャネル２０２を同時に受信し、どちらのチャネルが例えばパケットの送信に関連する信号を搬送しているかを決定し、元の周波数チャネルから他の周波数チャネルへ変換し、受信信号の周波数変換したバージョンを他のチャネルで再送信し得る。中継器の内部動作の詳細は、同時係属出願のＰＣＴ出願第ＰＣＴ／ＵＳ０３／１６２０８号に記載されている。

【００１７】

従って、中継器２００は、異なる周波数チャネルでパケットを同時に送受信でき、これによって、ＡＰ１００とクライアントユニット１０５との間の接続や、あるクライアントユニットから別のクライアントユニットへの接続のピアツーピア間の接続のカバレージ及び性能を拡張し得る。多くのユニットが互いに分離されている場合、中継器ユニット２００が更に無線ブリッジとして機能することにより、２つの異なるグループのユニットは、最適なＲＦ伝播及びカバレージ、又は多くの場合、任意のＲＦ伝播及びカバレージが従来可能でなかった所での、通信を行い得る。

【００１８】

様々な実施形態によれば、中継器２００は、好適には、信号を受信し、受信信号の周波数を変換し、例えば、図２に示す自動利得制御（ＡＧＣ）回路３００を介して例示の送受信機部の利得を適正に制御することによって、信号の歪や損失がほとんど無い状態にするように構成されている。好適な実施形態では、無線中継器２００は、２つの異なる周波数を同時に受信し、どちらが存在するか決定し、存在する方の周波数を他方の周波数に変換し、そして、受信信号の周波数変換したバージョンを再送信することができる。

【００１９】

１つの好適な例示の実施形態によれば、ＡＧＣ回路３００は、ＲＦ遅延及びフィルタ要素３０７－３１０を利用して、信号検出及び送信機構成を行いつつ、例示の受信波形をアナログ記憶することが可能である。信号検出が、ＲＦ遅延要素３０７－３１０における信号通過前及び信号通過時の両方で行われてもよく、その場合にシステム構成を実行する時間が提供され得ることに留意されたい。検出器電力レベルは、好適には、利得制御動作の一部として、並列の信号経路での利得値を設定するために用いられることに留意されたい

。
【0020】
ＡＧＣ回路３００は更に、対数増幅器３０１及び３０２、ＡＧＣ制御回路３０３及び３０４、好適には可変利得又は可変減衰器要素を含み得る利得制御要素３０５及び３０６、及び、例えば、好適には遅延回線及び／又は帯域通過フィルタ等のアナログ記憶装置を含み得るＲＦ遅延要素３０７－３１０が含まれる。更に好適には、低域フィルタ（ＬＰＦ）３１１及び３１２、並びにアナログーデジタル変換器（ＡＤＣ）３１３及び３１４が、例えば、プロセッサ３１５の指示及び制御下で利得制御を実現するために用いられる。
【0021】
中継器２００は、様々な実施形態によれば、２つの異なる周波数信号を同時に検出し処理するように構成されているため、受信信号３３０は、例えば、ＲＦスプリッタ３１６を用いて、分割され、２つの異なるＲＦ経路で伝播される。同様に、２つの異なる周波数経路は、別々に遅延されまた制御されなければならないため、各信号経路は、例えば、ＩＦスプリッタ３１７及び３１８によって更に分割される。ＩＦスプリッタ３１７からの一方の分割信号出力は、好適には、対数増幅器３０１に結合され、他方の分割信号出力は、好適には、利得制御要素３０５に結合される。同様に、ＩＦスプリッタ３１８からの一方の分割信号出力は、好適には、対数増幅器３０２に結合され、他方の分割信号出力は、好適には、利得制御要素３０６に結合される。対数増幅器３０１の出力は、ＡＧＣ制御回路３０３及び低域フィルタ３１１に供給される。同様に、対数増幅器３０２の出力は、ＡＧＣ制御回路３０４及び低域フィルタ３１２に供給される。対数増幅器３０１及び３０２は、好適には、受信信号３３０の電力の対数に比例する出力電圧を提供して、その包絡線を追跡するが、包絡線又は包絡線のサンプルを直接又は比例的に追跡するために当業者に周知の装置も用い得ることに留意されたい。
【0022】
例えば、低域フィルタ３１１及び３１２、アナログーデジタル変換器（ＡＤＣ）３１３及び３１４、及び、例えば、プロセッサ３１５等の、受信信号３３０の検出経路の構成要素の基本動作は、当業者には既に明白であるため、その基本動作の詳細な説明は省略する。このような動作は、同一の出願人に譲渡された同時係属出願のＰＣＴ特許出願第ＰＣＴ／ＵＳ０３／１６２０８号に詳細に開示されている。しかしながら、簡単に記すと、プロセッサ３１５は、好適には、検出経路ＤＥＴ１　３３１及びＤＥＴ２　３３２のＩＦ信号の存在を検出する。上記の同時係属出願において述べたように、信号検出は、例えば、プロセッサ３１５のアナログ又はデジタル信号比較手段を用いて、閾値を超える信号レベルに基づいてよく、あるいは、当業者に周知の他の手段によって実行されてもよい。信号が一旦検出されると、利得制御は、例えば、チャネルに応じて、それぞれＩＦ経路ＩＦ１　３３３又はＩＦ２　３３４のＡＧＣ制御回路３０３及び３０４を用いて、その信号に適用される。
【0023】
図面の図２をまた更に参照すると、利得制御は、ＡＧＣ制御回路３０３及び３０４が用いてＩＦ経路ＩＦ１　３３３及びＩＦ２　３３４の信号に適用されるが、ＡＧＣ制御回路３０３及び３０４が提供するのは、とりわけ、例えば、対数増幅器３０１及び３０２の出力におけるアナログ電圧のフィルタ処理、必要になる可能性がある任意のＤＣオフセット調整、ＡＧＣ設定値参照及び制御、レベルシフト処理／スケール変更処理、任意の要求される極性反転等、当業者に認識される処理である。ＡＧＣ制御回路３０３及び３０４の出力は利得制御要素３０５及び３０６に供給される。利得制御要素３０５及び３０６は、例えば、所望の送信機出力電力に関連する値に基づき、受信信号３３０の調整可能な利得又は調整可能な減衰を提供し得る。ＡＧＣ制御回路３０３及び３０４は、当業者に周知の様々な利得制御回路、装置等の１つであってよいことに留意されたい。
【0024】
様々な実施形態による利得制御の例として、次の条件の下で、利得制御要素３０５に可変減衰器を用い得る：所望の出力電力＋１５ｄＢｍ、受信信号電力－８０ｄＢｍ、総送受

信機損失６５ｄＢ、総送受信機利得１６５ｄＢ。
【００２５】
これらの条件下では、例えば、利得制御要素３０５に関連する可変減衰器は、関係式：Ｒｘ信号電力－所望出力電力＋総利得－総損失に従って、設定されるべきであり、従って減衰は、８０ｄＢｍ－１５ｄＢｍ＋１６５ｄＢ－６５ｄＢであり、５ｄＢの減衰となる。電圧を計算し、例えば、それをＡＧＣ制御回路３０３によって利得制御要素３０５に印加すると、所望の５ｄＢ減衰設定値となることを認識されたい。また、ＡＣＧ制御回路３０３及び利得制御要素３０５についてここで述べているが、上記説明は、ＡＧＣ制御回路３０４及び利得制御要素３０６の動作にも適用されることに留意されたい。
【００２６】
従って、様々な実施形態に従って、また、本例に従って再送信されるために、受信信号３３０は、好適には、利得制御要素３０５から出力され、表面弾性波（ＳＡＷ）フィルタ３０８及び３１０を介して遅延される。ＳＡＷフィルタ３０８及び３１０によってもたらされる遅延は、本質的に、アナログ波形を記憶するように機能し、他方、ＡＧＣ及び信号検出処理は、例えば上述した様に実行され、このことは、検出及び利得制御設定が、好適には、信号の伝播間隔時に完了されることを意味することを理解されたい。
【００２７】
様々な例示の実施形態及び好適な実施形態によれば、ＲＦ遅延は、ＳＡＷフィルタ３０７－３１０を介して課され、アナログ信号記憶及びチャネル選択、妨害電波抑制、及びフィードフォーワード可変利得制御経路がイネーブル状態になる。ＡＧＣ制御回路３０３及び３０４及び利得制御要素３０５及び３０６は、バイアスされるか、あるいは、例えば、好適には、当業者が理解されように、汎用プロセッサ、専用プロセッサ、信号処理プロセッサ等のプロセッサであるプロセッサ３１５の制御下で別な方法で設定し得る。更に、設定値は、どのチャネル受信信号３３０が受信されるか、また、どのチャネルが信号再送信用に選択されるかに依存して、プロセッサ３１５がルックアップテーブル等から得てもよい。異なる国では、帯域が異なると、送信電力の制限が異なり、従って、利得設定値の選択は、スペクトル再成長及び有効等方性放射電力（ＥＩＲＰ）等、所望の帯域に対するＦＣＣ要件及び関連する仕様を満たす必要性から生じる幾つかの因子によって決定され得ることに留意されたい。
【００２８】
利得制御の検出及び設定の後、ＩＦスイッチ３１９及びＬＯスイッチ３２０は、好適には、波形プリアンブルを大幅に遮断することなく、受信信号３３０を異なる周波数で再送信するように設定される。留意すべき重要なことは、例えば、検出及び電力検知は、上述した様に、好適には、検出器経路ＤＥＴ１　３３１及びＤＥＴ２　３３２で実行されるが、実際の利得制御は、ＩＦ経路ＩＦ１　３３３及びＩＦ２　３３４に適用し得ることである。より具体的には、再度図２において、対数増幅器３０１及び３０２からの出力が、ＡＧＣ制御回路３０３及び３０４に供給され、これらの回路が、利得制御要素３０５及び３０６に関して、可変利得又は減衰として調整を行う。
【００２９】
信号検出及び利得制御のシーケンスを決定する際の１つの因子は、対数増幅器３０１及び３０２からの出力電圧を、各々２つの異なるフィルタ帯域幅を潜在的に有する信号検出経路及び利得制御経路に分割することに起因する影響である。図２から分かるように、利得制御経路は、ＡＧＣ制御回路３０３及び３０４に至る経路であり、信号検出経路は、上述したように、低域フィルタ３１１及び３１２に至る経路である。従って、必要な場合、ＡＧＣ制御値及び信号検出フィルタ帯域幅は、異なるように設定し得る。例えば、ＡＧＣ制御ループは、入力電力包絡線に対してすばやく反応するように設定し得る一方で、例えば、ＡＤＣ３１３及び３１４並びにプロセッサ３１５で実行される信号検出は、よりゆっくりと反応するように構成し得る。その結果、利得制御要素３０５及び３０６を伝播する受信信号３３０は、極めて正確に追跡され得る一方で、ＡＤＣ３１３及び３１４並びにプロセッサ３１５を伝播する受信信号３３０の部分は、よりゆっくりと追跡され得るが、検

出処理利得はより大きい。

【００３０】

様々な例示の実施形態及び好適な実施形態によれば、受信信号３３０の存在を検出し、また、その電力レベルを検出して利得を設定するために、２つの別個の検出器が用いられることに留意されたい。従って、上述したように、信号検出は、ＡＧＣよりゆっくりと起こり得るため、異なる信号検出及びＡＧＣフィルタ帯域幅を用いて、利得制御要素３０５及び３０６等のＡＧＣに関連する可変制御要素がフィルタ３１１及び３１２の出力より速い又は遅い応答を有し得ると有益な場合がある。

【００３１】

利得制御の際の他の因子は、受信チャネルと送信チャネル間における相対的な距離である。具体的には、その間の距離に依存して、利得制御要素３０５及び３０６からの目標出力電力又は設定値は、受信チャネルと送信チャネルの周波数が更に離れると、追加の性能が得られる程度に異なり得る。性能要件を満たし続けつつ、利得制御要素３０５及び３０６の利得値は、大きくし得る。更に、ＡＧＣ制御回路３０３及び３０４は、周波数差異に基づき、電力を大きくするようにプログラムし得る。又は、他の選択肢として、プロセッサ３１５は、周波数分離に基づき、ＡＧＣ制御回路３０３及び３０４を制御するようにプログラムし得る。周波数分離に基づいて設定値を調整することは、更に、自己干渉を回避するために受信機によって傍受される任意の漏れ信号に対して更なるフィルタ処理を適用することを含み得る。

【００３２】

初期の中継器の起動時に、どのチャネルで動作するかの選択に影響を及ぼす因子は、異なるＦＣＣ帯域又は他の法的団体によって規制される帯域においてより大きな電力を送電する能力に基づき、中継チャネルを選択することによって影響を受け得る。例えば、米国で運用されるＵ－ＮＩＩ帯域では、ＣＨ３６－４８用の最大許容送信電力は、５０mWであり、ＣＨ５２－６４用は２５０mWであり、ＣＨ１４９－１６１用は1Wである。従って、より小さい電力帯域の１つに関連するチャネルで信号を受信し、また、より大きい送信電力を可能にする異なる帯域のチャネルを選択することが可能であり、これによって、より大きいＡＧＣ設定値が可能になる。従って、例えば、Ｆ１からＦ２へ及びＦ２からＦ１への変換に対する設定値は異なる。どのチャネルを選択するかの決定は、好適には、例えば、ＡＧＣ制御回路３０３及び３０４又はプロセッサ３１５において、製造時に予めプログラムするか、又は他の選択肢として、現場でプログラムし得る。

【００３３】

本発明の他の側面によれば、利得制御は、初期製造時に、ＡＧＣ較正が必要な場合がある。許容誤差がより小さい部品を使えるようにして、コストを低減するために、較正が望ましい場合がある。較正は、更に、地域的な又は帯域特有の電力設定値に必要な精度を提供し得る。従って、較正は、次の１つ又は複数、即ち、地域的な取締規制、周波数チャネル、受信電力レベル、送信電力レベル、温度等に従って、回路及び装置をセットアップすることを含み得る。様々な例示の実施形態及び好適な実施形態によれば、中継器２００は例えばプロセッサ３１５を用いて、較正テーブル等を記憶し、また、例えば、ソフトウェア、プログラム、命令等を用いて、ＡＧＣ制御回路３０５及び３０６に特定の較正値を受け渡すように構成されることが可能である。プロセッサ３１５は、好適には、デジタル－アナログ変換処理を利用して設定値を制御する。

【００３４】

上述のように、ＡＧＣ及び信号検出には異なる検出器出力を用いることが可能である。信号検出は、例えば、検出決定を行うために閾値比較器が用いるアナログ参照電圧を能動的に制御するように構成され得るプロセッサ３１５の制御下で、例えば、閾値比較器を用いてアナログだけの構成で実行し得る。他の選択肢として、受信信号３３０は、デジタル化することができ、検出決定は、例えば、プロセッサ３１５において成し得る。デジタル経路及びプロセッサ３１５の使用に関連する１つの問題として、例えば、プロセッサ３１５におけるデジタルサンプリング及び意思決定命令に関連する遅延が挙げられる。

【００３５】
様々な他の実施形態によれば、プロセッサ３１５によって制御される閾値を有するアナログ比較器（図示せず）を用いることが可能である。このような構成は、デジタル制御解除装置を備え、迅速な初期決定を可能にし、プロセッサ３１５によって判読可能で実行可能なソフトウェア、プログラム、命令等を用いて、より遅く更に正確で制御可能な決定に収斂し得る。例えば、混信が検出され、また、パケット継続時間が無線プロトコルが許容する時間より長いことをプロセッサ３１５が認識すると、ＡＧＣ制御回路３０３及び３０４及び／又は検出器は、信号送信を防止するために、プロセッサ３１５により停止され得る。従って、正常なＡＧＣ設定値が直接制御され、無効にされ得る。このような制御は、システムフィードバック発振が検出される場合を含む状況において、更に有用である。

【００３６】
当業者は、本発明において、ＡＧＣ設定値を決定すると共に種々の信号検出器の構成を決定するために、様々な技術を利用できることが理解されるだろう。さらに、利得制御要素３０５及び３０６、ＡＧＣ利得制御３０３及び３０４等の様々な要素、並びにプロセッサ３１５及び他の要素の機能を、１つの統合された装置に組み合わせることが可能である。特定の要素並びにそれらの相互接続に対する他の変更や修正は、本発明の範囲及び精神に逸脱することなく、当業者により行うことができる。

【００３７】
本発明を、現時点の好ましい実施形態に特に関連してここで詳細に説明したが、本発明の範囲及び精神内で変形や修正をなし得ることは理解されるだろう。

【図面の簡単な説明】

【００３８】
【図１】様々な実施形態に基づく自動利得制御を有する例示の中継器を含むＷＬＡＮを示す図。
【図２】図１の例示の中継器に関連する例示の利得制御回路を示す概略図。

【図１】

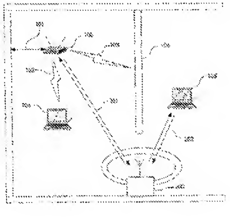
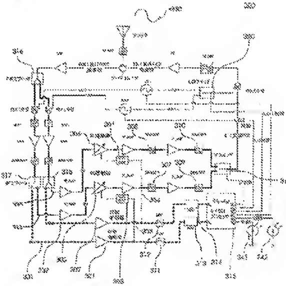


FIG. 1

【図２】



【国際調査報告】

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US03/29130

A. CLASSIFICATION OF SUBJECT MATTER
IPC(7) : H04B 7/15
US CL : 455/11.1, 127.1, 127.2, 136, 138
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 455/11.1, 127.1, 127.2, 136, 138

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6,404,775 B1 (LESLIE et al) 11 June 2002, see entire document.	1-39
A	US 5,726,980 A (RICKARD) 10 March 1998, see entire document.	1-39
A	US 2002/0109585 A1 (SANDERSON) 15 August 2002, see entire document.	1-39
A	US 2003/0185163 A1 (BERTONIS et al) 02 October 2003, see entire document.	1-39

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
07 January 2004 (07.01.2004)

Date of mailing of the international search report
21 JAN 2004

Name and mailing address of the ISA/US
Mail Stop PCT, Attn: ISA/US
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
Facsimile No. (703)305-3230

Authorized officer
Edan Orgad
Telephone No. 703-305-4233

Form PCT/ISA/210 (second sheet) (July 1998)

フロントページの続き

(81)指定国 AP(GH,GM,KE,LS,MW,MZ,SD,SL,SZ,TZ,UG,ZM,ZW),EA(AM,AZ,BY,KG,KZ,MD,RU,TJ,TM),EP(AT,BE,BG,CH,CY,CZ,DE,DK,EE,ES,FI,FR,GB,GR,HU,IE,IT,LU,MC,NL,PT,RO,SE,SI,SK,TR),OA(BF,BJ,CF,CG,CI,CM,GA,GN,GQ,GW,ML,MR,NE,SN,TD,TG),AE,AG,AL,AM,AT,AU,AZ,BA,BB,BG,BR,BY,BZ,CA,CH,CN,CO,CR,CU,CZ,DE,DK,DM,DZ,EC,EE,ES,FI,GB,GD,GE,GH,GM,HR,HU,ID,IL,IN,IS,JP,KE,KG,KP,KR,KZ,LC,LK,LR,LS,LT,LU,LV,MA,MD,MG,MK,MN,MW,MX,MZ,NO,NZ,OM,PH,PL,PT,RO,RU,SD,SE,SG,SK,SL,TJ,TM,TN,TR,TT,TZ,UA,UG,US,UZ,VN,YU,ZA,ZM,ZW

（特許庁注：以下のものは登録商標）
Ｂｌｕｅｔｏｏｔｈ
イーサネット

(72)発明者 プロクター、ジェームズ エイ．ジュニア
アメリカ合衆国 ３２９０１ フロリダ州 メルボルン スイート １０１２ ゲートウェイ ドライブ １３３３ ワイデファイ インコーポレイテッド

Ｆターム(参考) 5K072 AA29 BB25 BB27 CC02 CC28 EE20

【公報種別】特許法第１７条の２の規定による補正の掲載
【部門区分】第７部門第３区分
【発行日】平成18年11月24日(2006.11.24)

【公表番号】特表2006-503481(P2006-503481A)
【公表日】平成18年1月26日(2006.1.26)
【年通号数】公開・登録公報2006-004
【出願番号】特願2004-544751(P2004-544751)
【国際特許分類】
Ｈ０４Ｂ　7/15　(2006.01)
【ＦＩ】
Ｈ０４Ｂ　7/15　Ｚ

【手続補正書】
【提出日】平成18年10月4日(2006.10.4)
【手続補正１】
【補正対象書類名】特許請求の範囲
【補正対象項目名】全文
【補正方法】変更
【補正の内容】
【特許請求の範囲】
【請求項１】
時分割二重（ＴＤＤ）無線プロトコルシステムに使用される周波数変換中継器であって、
周波数変換中継器に関連する２つの周波数チャネルのうちの１つに信号が存在するか否かを検出するように構成された検出器回路；
前記信号に関連する周波数チャネルを前記２つの周波数チャネルのうちの一方から前記２つの周波数チャネルのうちの他方に変更するように構成された周波数変換器；及び
信号検出間隔及び送信機構成間隔を補償すべく、信号に遅延を付加するように構成された遅延回路；
を備えた周波数変換中継器。
【請求項２】
前記遅延回路はアナログ記憶装置を有する、請求項１に記載の周波数変換中継器。
【請求項３】
前記遅延回路は、アナログ信号記憶及びチャネル選択のうちの１又は複数に対して構成された少なくとも１つの表面弾性波フィルタを有する、請求項１に記載の周波数変換中継器。
【請求項４】
前記検出器回路はプロセッサを有する、請求項１に記載の周波数変換中継器。
【請求項５】
前記検出器回路はアナログ検出器をさらに有する、請求項４に記載の周波数変換中継器。
【請求項６】
利得制御回路をさらに有し、該利得制御回路はそれに関連する利得値及び減衰値のうちの１つを備えている、請求項１に記載の周波数変換中継器。
【請求項７】
前記検出器は、信号の受信信号強度をさらに検出するためのものであり、前記利得制御回路は、信号の利得値を調整するために該信号の受信信号強度をさらに使用するためのものである、請求項６に記載の周波数変換中継器。
【請求項８】

前記利得制御回路は、特定の信号送信出力電力を達成するために、所定の基準に基づいて前記利得値及び前記減衰値のうちの少なくとも１つをさらに制御するためのものである、請求項７に記載の周波数変換中継器。
【請求項９】
前記所定の基準は、特定の信号送信出力電力を修正するためのものであり、受信周波数と送信周波数の間の周波数分離、取締規則、温度、受信電力レベル、送信電力レベル、及び検出された干渉レベルのうちの少なくとも１つを含んでいる、請求項８に記載の周波数変換中継器。
【請求項１０】
プロセッサはさらにメモリを有し、前記所定の基準が該メモリに格納される、請求項８に記載の周波数変換中継器。
【請求項１１】
時分割二重（ＴＤＤ）無線プロトコルシステムに使用される周波数変換中継器であって、
周波数変換中継器に関連する２つの周波数チャネルのうちの１つに信号が存在するか否かを検出し、かつ信号の受信検出信号電力を検出するように構成された検出器回路；
前記信号に関連する周波数チャネルを２つの周波数チャネルのうちの一方から２つの周波数チャネルのうちの他方に変更するように構成された周波数変換器；
信号検出間隔及び送信機構成間隔を補償すべく、信号に遅延を付加するように構成された遅延回路；及び　前記検出器回路によって検出された受信検出信号電力に少なくとも一部基づいて、信号の利得値を調整するように構成された利得制御回路；
を備えた周波数変換中継器。
【請求項１２】
前記利得制御回路は、２つの周波数チャネルのうちのどちらの一方で信号が受信され、２つの周波数チャネルのうちのどちらの他方に変更されるかを含む基準に少なくとも一部基づいて、利得値を調整するように構成されている、請求項１１に記載の周波数変換中継器。
【請求項１３】
前記基準が、送信のための取締規則、動作温度、及び受信周波数と送信周波数の間の周波数分離のうちの少なくとも１つをさらに含んでいる、請求項１２に記載の周波数変換中継器。
【請求項１４】
前記基準が、受信周波数と送信周波数の間の距離をさらに含み、前記自動利得制御回路は、該距離に基づいて信号に対してよりフィルタ処理を適用するようにさらに構成されている、請求項１１に記載の周波数変換中継器。
【請求項１５】
時分割二重（ＴＤＤ）無線プロトコルシステムに使用される周波数変換中継器であって、
周波数変換中継器に関連する２つの周波数チャネルのうちの１つに信号が存在するか否かを検出するように構成された検出器回路；
前記信号を無線周波数（ＲＥ）信号から中間周波数（ＩＦ）信号に変換するように構成された周波数変換機；
前記ＩＦ信号に関連する周波数チャネルを２つの周波数チャネルのうちの一方から２つの周波数チャネルのうちの他方に変更するように構成された周波数変換器；
信号検出間隔及び送信機構成間隔を補償すべく、前記ＩＦ信号に遅延を付加するように構成された遅延回路；及び
前記ＩＦ信号の利得値を調整するように構成された利得制御回路；
を備えた周波数変換中継器。
【請求項１６】
前記利得制御回路が、検出器回路によって検出された受信検出信号電力に少なくとも一

部基づいて、ＩＦ信号の利得値を調整するようにさらに構成されている、請求項１５に記載の周波数変換中継器。

【請求項１７】

前記検出器回路及び前記利得制御回路は、第１の信号経路と第２の信号経路にそれぞれ位置する、請求項１５に記載の周波数変換中継器。

【請求項１８】

前記検出器回路は対数増幅器を有し、該対数増幅器の出力は該出力を制御するために利得制御回路に結合されている、請求項１７に記載の周波数変換中継器。

【請求項１９】

前記検出器回路及び前記自動利得制御回路は各々異なる帯域幅を有している、請求項１８に記載の周波数変換中継器。

【請求項２０】

前記自動利得制御回路はプロセッサと、所定の基準を格納するメモリとを有し、プロセッサはＩＦ信号のオフセット利得値を確立するために前記所定の基準を使用するように構成されており、検出器回路によって検出される信号の検出受信電力とは無関係に、送信機の目標出力電力が少なくとも一部生じる、請求項１９に記載の周波数変換中継器。

【請求項２１】

前記プロセッサは、

対数増幅器の出力をデジタル信号に変換し；かつ　該デジタル信号を使用してＩＦ信号の利得値を確立する；ようにさらに構成されている、請求項２０に記載の周波数変換中継器。

【請求項２２】

時分割二重（ＴＤＤ）無線プロトコルシステムに使用される周波数変換中継器における周波数変換の方法であって、

周波数変換中継器に関連する２つの周波数チャネルのうちの１つに信号が存在するか否かを検出すること；

前記信号に関連する周波数チャネルを２つの周波数チャネルのうちの一方から２つの周波数チャネルのうちの他方に変更すること；及び

信号検出間隔及び送信機構成間隔に等しく、信号に遅延を付加すること；

から成る方法。

【請求項２３】

前記遅延を付加することは、アナログ記憶装置の信号を遅延させることを含む、請求項２２に記載の方法。

【請求項２４】

前記遅延を付加することは、アナログ信号記憶及びチャネル選択のうちの１又は複数に対して構成された少なくとも１つの表面弾性波フィルタの信号を遅延させることを含む、請求項２２に記載の方法。

【請求項２５】

前記検出することは、アナログ検出器において検出することを含む、請求項２４に記載の方法。

【請求項２６】

前記信号に関連する利得を設定することをさらに含む、請求項２２に記載の方法。

【請求項２７】

前記利得を設定することは、前記所定の基準に少なくとも一部基づいて利得を設定することをさらに含む、請求項２６に記載の方法。

【請求項２８】

前記所定の基準は、受信周波数と送信周波数の間の距離、取締規則、温度、受信電力レベル、送信電力レベル、及び検出された干渉レベルのうちの少なくとも１つを含んでいる、請求項２７に記載の方法。

【請求項２９】

前記所定の基準をメモリに格納することをさらに含む、請求項２８に記載の方法。
【請求項３０】
時分割二重（ＴＤＤ）無線プロトコルシステムに使用される周波数変換中継器における周波数変換の方法であって、
周波数変換中継器に関連する２つの周波数チャネルのうちの１つに信号が存在するか否かを検出すること；
前記信号に関連する周波数チャネルを２つの周波数チャネルのうちの一方から２つの周波数チャネルのうちの他方に変更すること；
信号検出間隔及び送信機形状間隔を補償すべく、信号に遅延を付加すること；及び
前記信号の検出受信電力レベルに少なくとも一部基づいて、信号の利得値を調整すること；
から成る方法。
【請求項３１】
前記利得値を調整することは、２つの周波数チャネルのうちのどちらの一方で信号が受信され、２つの周波数チャネルのうちのどちらの他方に変更されるかを含む基準に基づいている、請求項３０に記載の方法。
【請求項３２】
前記基準は、送信のための取締規則をさらに含む、請求項３０に記載の方法。
【請求項３３】
前記基準は、受信周波数と送信周波数の間の周波数分離をさらに含む、請求項３１に記載の方法。
【請求項３４】
時分割二重（ＴＤＤ）無線プロトコルシステムに使用される周波数変換中継器における周波数変換の方法であって、
周波数変換中継器に関連する２つの周波数チャネルのうちの１つに信号が存在するか否かを検出し、存在する場合に、信号の受信電力レベルを検出すること；
前記信号を無線周波数（ＲＦ）信号から中間周波数（ＩＦ）信号に変換すること；
前記ＩＦ信号に関連する周波数チャネルを２つの周波数チャネルのうちの一方から２つの周波数チャネルのうちの他方に変更すること；
信号検出間隔及び送信機構成間隔を補償すべく、前記ＩＦ信号に遅延を付加すること；及び
前記信号の検出受信電力レベルに少なくとも一部基づいて、前記ＩＦ信号の利得値を調整すること；
から成る方法。
【請求項３５】
前記検出と前記調整が、第１の信号経路と第２の信号経路でそれぞれ行なわれる、請求項３４に記載の方法。
【請求項３６】
前記検出が、前記信号から対数信号を生成し、該対数信号を前記調整のために使用することを含む、請求項３５に記載の方法。
【請求項３７】
前記調整が、所定の基準を使用して、前記ＩＦ信号の利得値を調整することをさらに含む、請求項３６に記載の方法。
【請求項３８】
前記生成は、対数信号をデジタル信号に変換することをさらに含み、前記調整は、該デジタル信号を使用してＩＦ信号の利得値をさらに調整することを含む、請求項３６に記載の方法。
【請求項３９】
時分割二重通信システムに使用される周波数変換中継器であって、
少なくとも第１の周波数チャネルと第２の周波数チャネルで送信を受け取ることが可能

な少なくとも２つの受信機；
前記第１の周波数チャネルで送信することが可能な少なくとも１つの送信機；
第２の周波数チャネルで送信することが可能な少なくとも１つの送信機；
周波数変換中継器に関連する２つの周波数チャネルのうちの１つに信号が存在するか否かを検出し、かつ信号の受信電力レベルを検出するように構成された検出器回路；
前記信号に関連する周波数チャネルを前記第１及び第２の周波数チャネルのうちの最初のチャネルから前記第１及び第２の周波数チャネルのうちの次のチャネルに変更するように構成された周波数変換器；及び
マイクロプロセッサに格納された所定のパラメータに基づいて第１及び第２の周波数チャネルを構成することが可能なマイクロプロセッサ；
を備え、
第１及び第２の周波数チャネルの少なくとも１つに対する特定周波数の構成は、前記所定のパラメータに基づいており、
前記所定のパラメータは、取締送信機パワー制限、取締帯域外放射制限、及び第１周波数チャネルと第２周波数チャネル間の周波数分離、の少なくとも１つを含んでいる、周波数変換中継器。

US 20030124976A1

(19) **United States**

(12) **Patent Application Publication**

(10) **Pub. No.: US 2003/0124976 A1**

Tamaki et al.

(43) **Pub. Date: Jul. 3, 2003**

(54) **MULTI POINT WIRELESS TRANSMISSION REPEATER SYSTEM AND WIRELESS EQUIPMENTS**

(76) Inventors: **Tsuyoshi Tamaki**, Hachioji (JP); **Katsumi Sakai**, Hitachi (JP); **Takashi Yano**, Tokorozawa (JP)

Correspondence Address:
ANTONELLI TERRY STOUT AND KRAUS
SUITE 1800
1300 NORTH SEVENTEENTH STREET
ARLINGTON, VA 22209

(21) Appl. No.: **10/192,164**

(22) Filed: **Jul. 11, 2002**

(30) **Foreign Application Priority Data**

Dec. 28, 2001 (JP) 2001-399800

Publication Classification

(51) **Int. Cl.**^{7} **H04B 7/14**

(52) **U.S. Cl.** **455/15**; 455/561; 455/522

(57) **ABSTRACT**

A communication system having an excellent communication path capacity characteristic even in an insight transmission environment in which a transmitter and a receiver can see each other directly in an MIMO communication system and a wireless communication device for the communication system, including: a wireless device having a transmitter for distributing transmission data including encoded data and a training signal to a plurality of antennas, and transmitting the data as radio signals from the plurality of antennas at a predetermined timing, a plurality of wireless devices having repeaters each for receiving the radio signal, storing the radio signal into a buffer so that the radio signal is delayed by predetermined time, and transmitting the radio signal delayed, and a wireless device having a receiver for receiving the radio signals from the plurality of second wireless devices by a plurality of antennas and demodulating the encoded data by using the training signal multiplexed on the received radio signal. Each wireless device determines whether relaying operation is necessary or not and transmits a control signal for controlling the relaying operation.

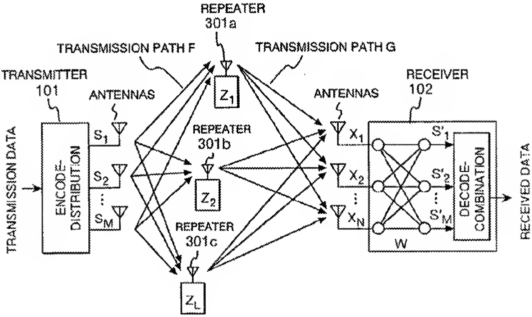


FIG. 1

PRIOR ART

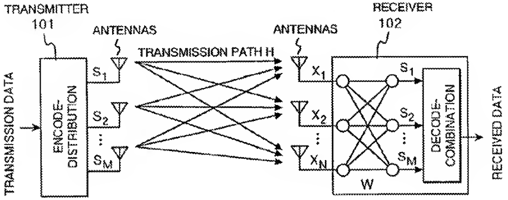


FIG. 2a

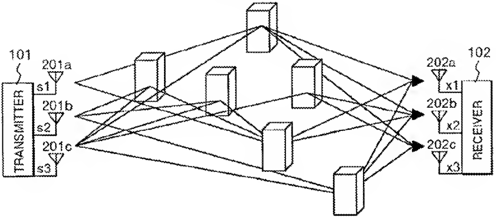


FIG. 2b

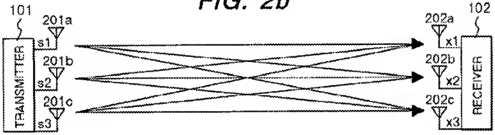


FIG. 2c

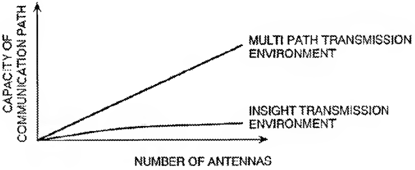
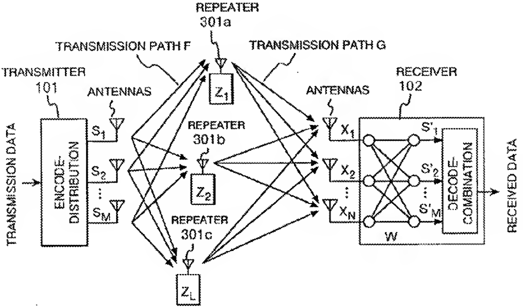


FIG. 3



REPEATER
301a
TRANSMISSION PATH F
TRANSMISSION PATH G
TRANSMITTER
101
ANTENNAS
Z_1
ANTENNAS
RECEIVER
102
TRANSMISSION DATA
ENCODE-DISTRIBUTION
S_1
S_2
S_M
REPEATER
301b
Z_2
REPEATER
301c
Z_L
X_1
X_2
X_N
S'_1
S'_2
S'_M
W
DECODE-COMBINATION
RECEIVED DATA

FIG. 4

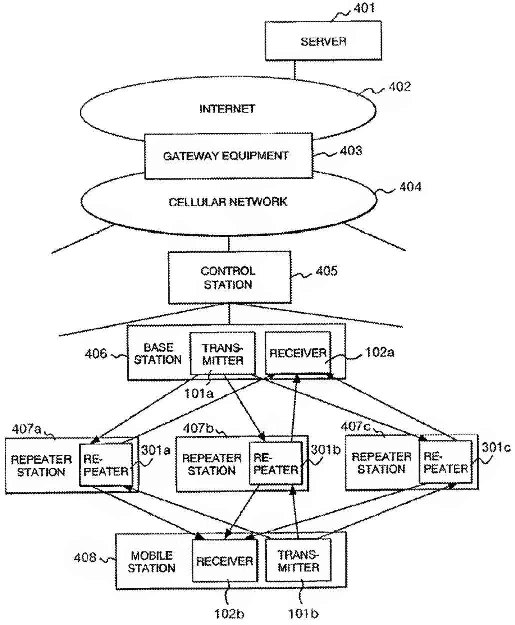

401
SERVER
402
INTERNET
GATEWAY EQUIPMENT
403
CELLULAR NETWORK
404
CONTROL STATION
405
406
BASE STATION
TRANS-MITTER
RECEIVER
102a
101a
407a
REPEATER STATION
RE-PEATER
301a
407b
REPEATER STATION
RE-PEATER
301b
407c
REPEATER STATION
RE-PEATER
301c
408
MOBILE STATION
RECEIVER
TRANS-MITTER
102b
101b

FIG. 5

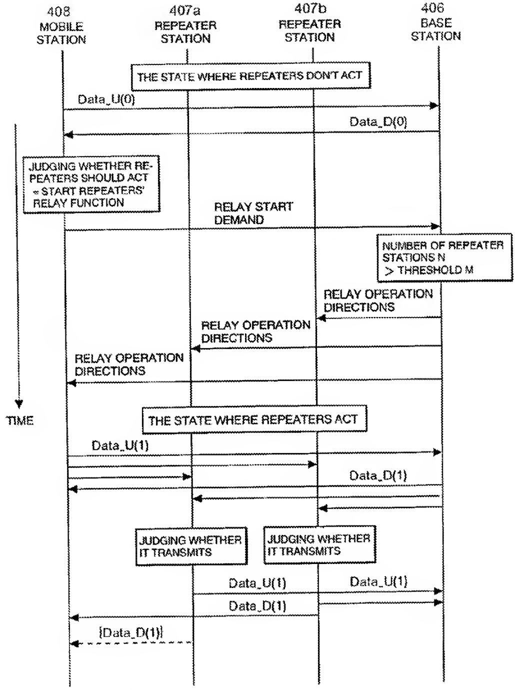

408
MOBILE STATION
407a
REPEATER STATION
407b
REPEATER STATION
406
BASE STATION
THE STATE WHERE REPEATERS DON'T ACT
Data_U(0)
Data_D(0)
JUDGING WHETHER REPEATERS SHOULD ACT = START REPEATERS' RELAY FUNCTION
RELAY START DEMAND
NUMBER OF REPEATER STATIONS N > THRESHOLD M
RELAY OPERATION DIRECTIONS
RELAY OPERATION DIRECTIONS
RELAY OPERATION DIRECTIONS
TIME
THE STATE WHERE REPEATERS ACT
Data_U(1)
Data_D(1)
JUDGING WHETHER IT TRANSMITS
JUDGING WHETHER IT TRANSMITS
Data_U(1)
Data_U(1)
Data_D(1)
{Data_D(1)}

FIG. 6a

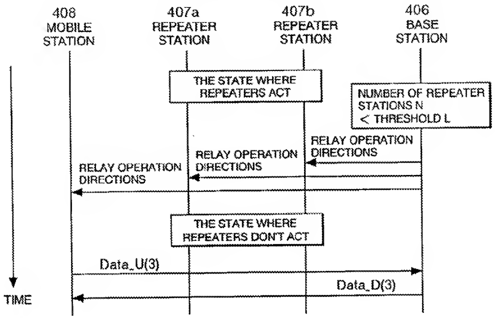

408
MOBILE
STATION
407a
REPEATER
STATION
407b
REPEATER
STATION
406
BASE
STATION
THE STATE WHERE
REPEATERS ACT
NUMBER OF REPEATER
STATIONS N
< THRESHOLD L
RELAY OPERATION
DIRECTIONS
RELAY OPERATION
DIRECTIONS
RELAY OPERATION
DIRECTIONS
THE STATE WHERE
REPEATERS DON'T ACT
Data_U(3)
Data_D(3)
TIME

FIG. 6b

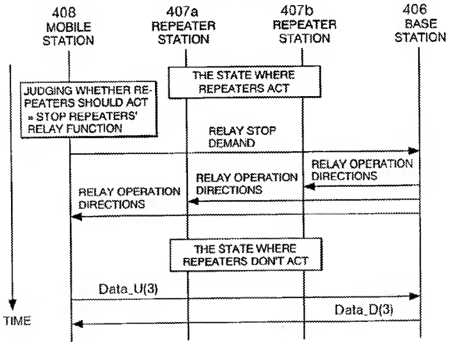

408
MOBILE
STATION
407a
REPEATER
STATION
407b
REPEATER
STATION
406
BASE
STATION
THE STATE WHERE
REPEATERS ACT
JUDGING WHETHER RE-
PEATERS SHOULD ACT
= STOP REPEATERS'
RELAY FUNCTION
RELAY STOP
DEMAND
RELAY OPERATION
DIRECTIONS
RELAY OPERATION
DIRECTIONS
RELAY OPERATION
DIRECTIONS
THE STATE WHERE
REPEATERS DON'T ACT
Data_U(3)
Data_D(3)
TIME

FIG. 7a

RELAY START DEMAND, RELAY STOP DEMAND
: MOBILE STATION —> BASE STATION

← 32bit →

LEN [31:16]	MSG [15:8]	Opr [7:0]	LINK DIRECTION
Num_M [31:16]	Num_L [15:0]		NUMBER OF REPEATERS

RELAY START DEMAND : LEN=0x02, MSG=0x01, Opr=0x01,
RELAY STOP DEMAND : LEN=0x02, MSG=0x02, Opr=0x01,

FIG. 7b

RELAY OPERATION DIRECTIONS (START RELAY, UPDATE PARAMETERS)
: BASE STATION —> MOBILE STATION, REPEATER STATION

← 32bit →

LEN [31:16]		MSG [15:8]	Opr [7:0]	LINK DIRECTION
UID [31:0]				STATION ID
DST [31:24]	DLEN [23:16]	UST [15:8]	ULEN [7:0]	TRANSCEIVER TIMING
RXL [31:16]		TXL [15:0]		THE JUDGMENT STANDARD OF RELAY
GAIN_K [31:0]				TRANSMISSION POWER OF REPEATER

START RELAY : LEN=0x05, MSG=0x03, Opr=0x02, ···
UPDATE PARAMETERS : LEN=0x05, MSG=0x04, Opr=0x02, ···

FIG. 7c

RELAY OPERATION DIRECTIONS (STOP RELAY)
: BASE STATION —> MOBILE STATION, REPEATER STATION

← 32bit →

LEN [31:16]	MSG [15:8]	Opr [7:0]	LINK DIRECTION
UID [31:0]			STATION ID

STOP RELAY : LEN=0x02, MSG=0x05, Opr=0x02, ···

FIG. 8

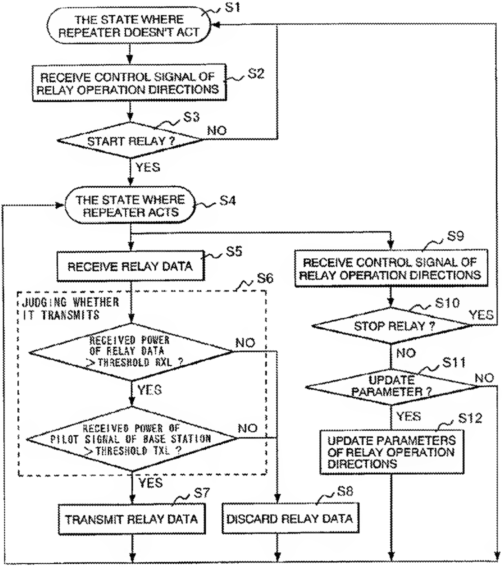

THE STATE WHERE REPEATER DOESN'T ACT
S1
RECEIVE CONTROL SIGNAL OF RELAY OPERATION DIRECTIONS
S2
START RELAY ?
S3
NO
YES
THE STATE WHERE REPEATER ACTS
S4
RECEIVE RELAY DATA
S5
S6
JUDGING WHETHER IT TRANSMITS
RECEIVED POWER OF RELAY DATA >THRESHOLD RXL ?
NO
YES
RECEIVED POWER OF PILOT SIGNAL OF BASE STATION >THRESHOLD TXL ?
NO
YES
TRANSMIT RELAY DATA
S7
DISCARD RELAY DATA
S8
RECEIVE CONTROL SIGNAL OF RELAY OPERATION DIRECTIONS
S9
STOP RELAY ?
S10
YES
NO
UPDATE PARAMETER ?
S11
NO
YES
UPDATE PARAMETERS OF RELAY OPERATION DIRECTIONS
S12

FIG. 9a

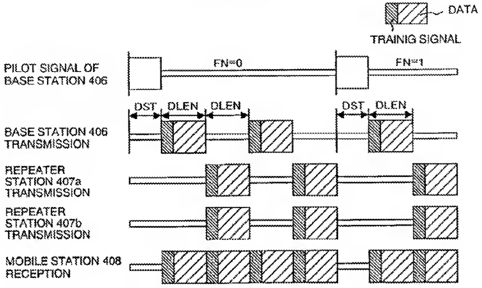

DATA
TRAINIG SIGNAL
PILOT SIGNAL OF BASE STATION 406
FN=0
FN=1
DST
DLEN
DLEN
DST
DLEN
BASE STATION 406 TRANSMISSION
REPEATER STATION 407a TRANSMISSION
REPEATER STATION 407b TRANSMISSION
MOBILE STATION 408 RECEPTION

FIG. 9b

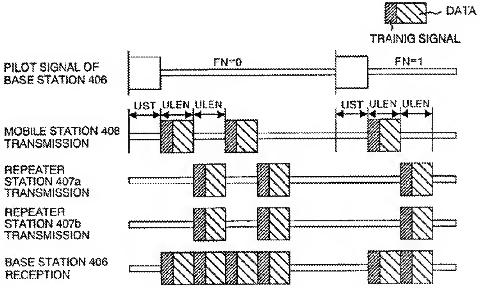
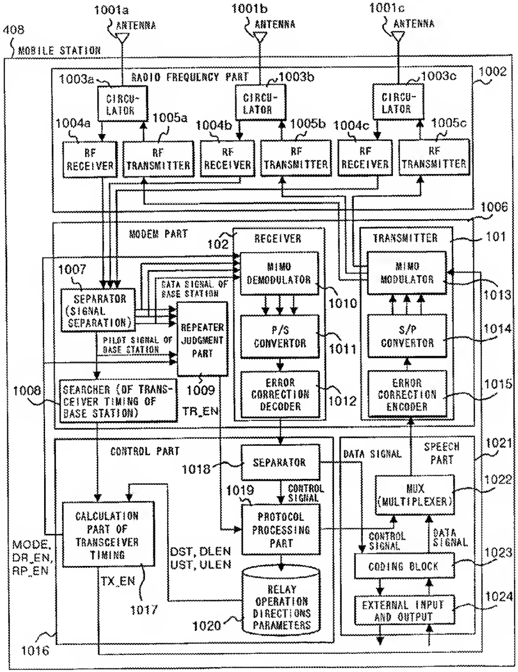

DATA
TRAINIG SIGNAL
PILOT SIGNAL OF BASE STATION 406
FN=0
FN=1
UST
ULEN
ULEN
UST
ULEN
ULEN
MOBILE STATION 408 TRANSMISSION
REPEATER STATION 407a TRANSMISSION
REPEATER STATION 407b TRANSMISSION
BASE STATION 406 RECEPTION

FIG. 10



1001a
ANTENNA
1001b
ANTENNA
1001c
ANTENNA
408
MOBILE STATION
1003a
RADIO FREQUENCY PART
1003b
1003c
1002
CIRCU-LATOR
CIRCU-LATOR
CIRCU-LATOR
1004a
1005a
1004b
1005b
1004c
1005c
RF RECEIVER
RF TRANSMITTER
RF RECEIVER
RF TRANSMITTER
RF RECEIVER
RF TRANSMITTER
1006
MODEM PART
102
RECEIVER
TRANSMITTER
101
1007
MIMO DEMODULATOR
MIMO MODULATOR
SEPARATOR (SIGNAL SEPARATION)
DATA SIGNAL OF BASE STATION
1010
1013
REPEATER JUDGMENT PART
P/S CONVERTOR
S/P CONVERTOR
1014
PILOT SIGNAL OF BASE STATION
1011
1008
SEARCHER (OF TRANS-CEIVER TIMING OF BASE STATION)
1009
ERROR CORRECTION DECODER
1012
ERROR CORRECTION ENCODER
1015
TR_EN
CONTROL PART
SEPARATOR
DATA SIGNAL
SPEECH PART
1021
1018
1022
1019
CONTROL SIGNAL
MUX (MULTIPLEXER)
CALCULATION PART OF TRANSCEIVER TIMING
PROTOCOL PROCESSING PART
CONTROL SIGNAL
DATA SIGNAL
MODE, DR_EN, RP_EN
DST, DLEN
UST, ULEN
1023
CODING BLOCK
TX_EN
RELAY OPERATION DIRECTIONS PARAMETERS
1017
EXTERNAL INPUT AND OUTPUT
1024
1020
1016

FIG. 11a

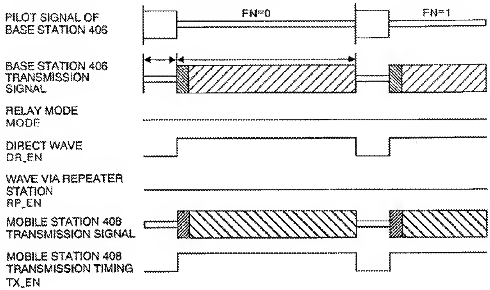


FIG. 11b

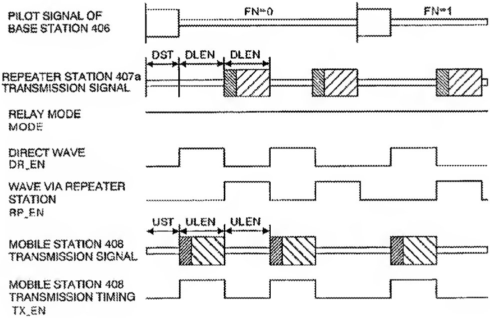
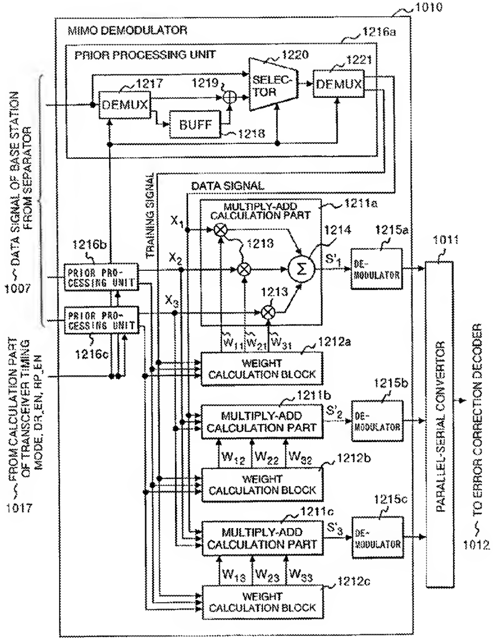


FIG. 12



1010
MIMO DEMODULATOR
1216a
PRIOR PROCESSING UNIT
1220
1221
1217
1219
SELEC-TOR
DEMUX
DEMUX
BUFF
1218
DATA SIGNAL OF BASE STATION FROM SEPARATOR
1007
TRAINING SIGNAL
DATA SIGNAL
MULTIPLY-ADD CALCULATION PART
1211a
1214
1215a
1011
1213
1216b
PRIOR PRO-CESSING UNIT
PRIOR PRO-CESSING UNIT
1216c
DE-MODULATOR
1212a
WEIGHT CALCULATION BLOCK
FROM CALCULATION PART OF TRANSCEIVER TIMING MODE, DR_EN, RP_EN
1017
1211b
1215b
MULTIPLY-ADD CALCULATION PART
1212b
WEIGHT CALCULATION BLOCK
1211c
1215c
MULTIPLY-ADD CALCULATION PART
1212c
WEIGHT CALCULATION BLOCK
PARALLEL-SERIAL CONVERTOR
TO ERROR CORRECTION DECODER
1012

FIG. 13

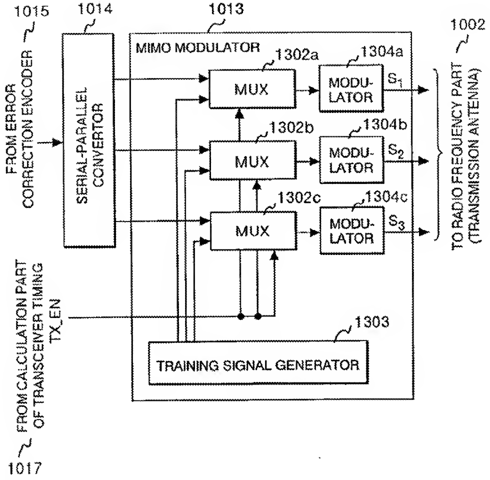

1015
FROM ERROR CORRECTION ENCODER
1014
SERIAL-PARALLEL CONVERTOR
1013
MIMO MODULATOR
1302a
MUX
1304a
MODU-LATOR
S_1
1302b
MUX
1304b
MODU-LATOR
S_2
1302c
MUX
1304c
MODU-LATOR
S_3
1002
TO RADIO FREQUENCY PART (TRANSMISSION ANTENNA)
FROM CALCULATION PART OF TRANSCEIVER TIMING TX_EN
1017
1303
TRAINING SIGNAL GENERATOR

FIG. 14

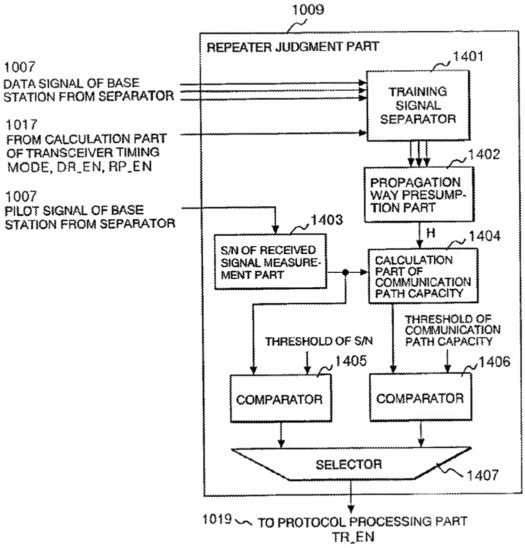

1009
REPEATER JUDGMENT PART
1401
1007
DATA SIGNAL OF BASE STATION FROM SEPARATOR
TRAINING SIGNAL SEPARATOR
1017
FROM CALCULATION PART OF TRANSCEIVER TIMING
MODE, DR_EN, RP_EN
1402
PROPAGATION WAY PRESUMPTION PART
1007
PILOT SIGNAL OF BASE STATION FROM SEPARATOR
1403
H
1404
S/N OF RECEIVED SIGNAL MEASUREMENT PART
CALCULATION PART OF COMMUNICATION PATH CAPACITY
THRESHOLD OF COMMUNICATION PATH CAPACITY
THRESHOLD OF S/N
1405
1406
COMPARATOR
COMPARATOR
SELECTOR
1407
1019
TO PROTOCOL PROCESSING PART
TR_EN

FIG. 15

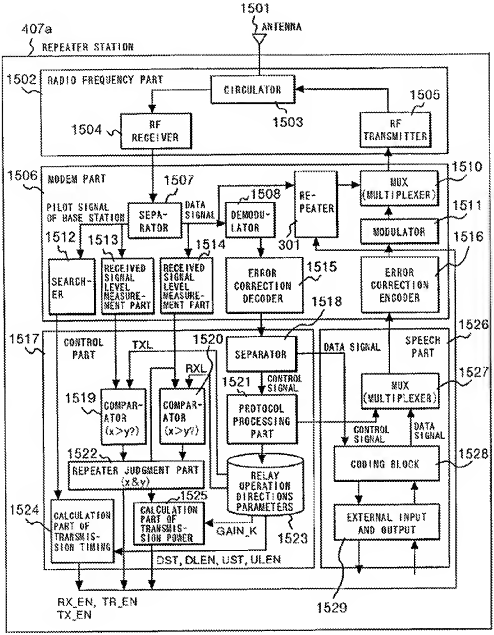

1501
ANTENNA
407a
REPEATER STATION
1502
RADIO FREQUENCY PART
CIRCULATOR
1503
1505
1504
RF RECEIVER
RF TRANSMITTER
1506
MODEM PART
1507
1508
1510
MUX (MULTIPLEXER)
PILOT SIGNAL OF BASE STATION
SEPA-RATOR
DATA SIGNAL
DEMODU-LATOR
RE-PEATER
1511
MODULATOR
1512
1513
1514
301
1516
SEARCH-ER
RECEIVED SIGNAL LEVEL MEASURE-MENT PART
RECEIVED SIGNAL LEVEL MEASURE-MENT PART
ERROR CORRECTION DECODER
1515
ERROR CORRECTION ENCODER
1518
1526
1517
CONTROL PART
TXL
1520
SEPARATOR
DATA SIGNAL
SPEECH PART
RXL
1527
1521
CONTROL SIGNAL
MUX (MULTIPLEXER)
1519
COMPAR-ATOR (x>y?)
COMPAR-ATOR (x>y?)
PROTOCOL PROCESSING PART
CONTROL SIGNAL
DATA SIGNAL
1522
REPEATER JUDGMENT PART (x&y)
RELAY OPERATION DIRECTIONS PARAMETERS
CODING BLOCK
1528
1525
1524
CALCULATION PART OF TRANSMIS-SION TIMING
CALCULATION PART OF TRANSMIS-SION POWER
GAIN_K
1523
EXTERNAL INPUT AND OUTPUT
DST, DLEN, UST, ULEN
RX_EN, TR_EN
TX_EN
1529

FIG. 16

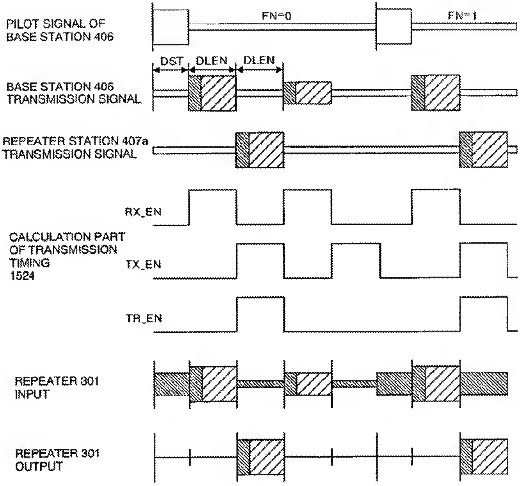
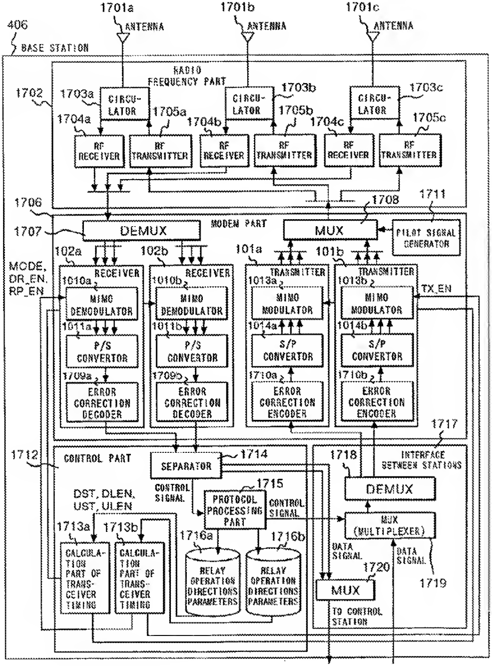

PILOT SIGNAL OF BASE STATION 406
FN=0
FN=1
DST
DLEN
DLEN
BASE STATION 406 TRANSMISSION SIGNAL
REPEATER STATION 407a TRANSMISSION SIGNAL
RX_EN
CALCULATION PART OF TRANSMISSION TIMING 1524
TX_EN
TR_EN
REPEATER 301 INPUT
REPEATER 301 OUTPUT

FIG. 17



406
BASE STATION
1701a
ANTENNA
1701b
ANTENNA
1701c
ANTENNA
1702
RADIO FREQUENCY PART
1703a
CIRCU-LATOR
1703b
CIRCU-LATOR
1703c
CIRCU-LATOR
1704a
1705a
1704b
1705b
1704c
1705c
RF RECEIVER
RF TRANSMITTER
RF RECEIVER
RF TRANSMITTER
RF RECEIVER
RF TRANSMITTER
1706
1708
1711
MODEM PART
1707
DEMUX
MUX
PILOT SIGNAL GENERATOR
102a
102b
101a
101b
MODE, DR_EN, RP_EN
RECEIVER
RECEIVER
TRANSMITTER
TRANSMITTER
TX_EN
1010a
1010b
1013a
1013b
MIMO DEMODULATOR
MIMO DEMODULATOR
MIMO MODULATOR
MIMO MODULATOR
1011a
1011b
1014a
1014b
P/S CONVERTOR
P/S CONVERTOR
S/P CONVERTOR
S/P CONVERTOR
1709a
1709b
1710a
1710b
ERROR CORRECTION DECODER
ERROR CORRECTION DECODER
ERROR CORRECTION ENCODER
ERROR CORRECTION ENCODER
1717
1712
CONTROL PART
SEPARATOR
1714
1718
INTERFACE BETWEEN STATIONS
CONTROL SIGNAL
1715
DEMUX
DST, DLEN, UST, ULEN
PROTOCOL PROCESSING PART
CONTROL SIGNAL
MUX (MULTIPLEXER)
1713a
1713b
1716a
1716b
DATA SIGNAL
DATA SIGNAL
CALCULA-TION PART OF TRANS-CEIVER TIMING
CALCULA-TION PART OF TRANS-CEIVER TIMING
RELAY OPERATION DIRECTIONS PARAMETERS
RELAY OPERATION DIRECTIONS PARAMETERS
1720
1719
MUX
TO CONTROL STATION

FIG. 18a

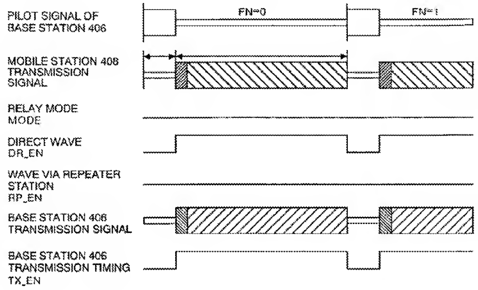


FIG. 18b

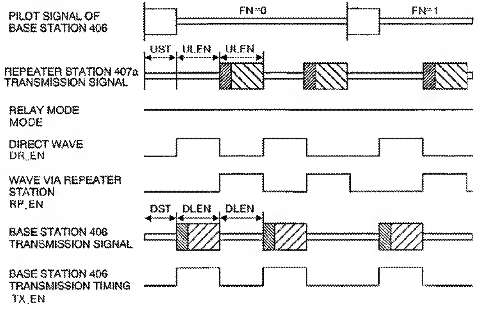


FIG. 19

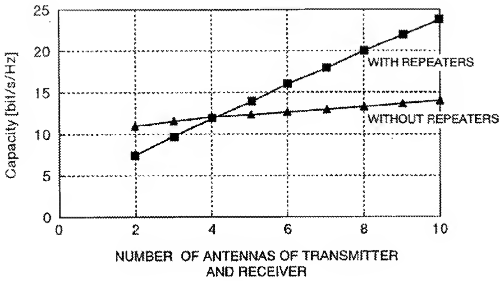
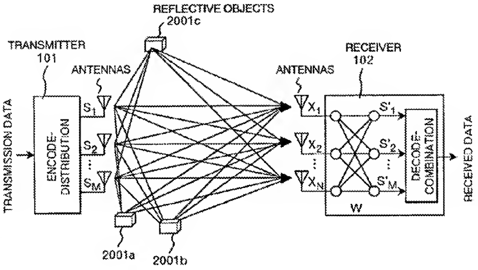

25
20
15
10
5
0
Capacity [bit/s/Hz]
0
2
4
6
8
10
WITH REPEATERS
WITHOUT REPEATERS
NUMBER OF ANTENNAS OF TRANSMITTER AND RECEIVER

FIG. 20


REFLECTIVE OBJECTS
2001c
TRANSMITTER
101
ANTENNAS
RECEIVER
102
ANTENNAS
TRANSMISSION DATA
ENCODE-DISTRIBUTION
S1
S2
SM
X1
X2
XN
S'1
S'2
S'M
DECODE-COMBINATION
W
RECEIVED DATA
2001a
2001b

MULTI POINT WIRELESS TRANSMISSION REPEATER SYSTEM AND WIRELESS EQUIPMENTS

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a wireless transmission repeater system and wireless equipment for use in the system. More particularly, the invention relates to a wireless transmission repeater system in which a plurality of repeaters are disposed between a transmitter and a receiver in a wireless transmission repeater system such as a mobile communication system, and wireless equipment used for the system.

[0003] 2. Description of the Related Art

[0004] In a conventional mobile communication system, to improve reception sensitivity of a receiver of a radio signal transmitted via a transmission antenna from a transmitter, selective diversity reception of employing two reception antennas and using a reception signal from the antenna of a higher signal-to-noise (S/N) ratio, and synthetic diversity reception of adding signals from two reception antennas in accordance with the S/N ratio are known. In a 3GPP (Third Generation Partnership Project) as one of standardization organizations of third-generation mobile communication standards, a transmission diversity technique of improving reception sensitivity of a receiver by making a path (propagation path) of a radio signal to the receiver insusceptible to the influence of obstacles from the viewpoint of probability by transmitting the same signal from two transmission antennas is known.

[0005] A standardization organization (3GPP2) examining a communication system different from the 3GPP has proposed a communication system (MIMO: Multiple Input Multiple Output) such that, as shown in **FIG. 1**, a transmitter **101** transmits transmission data so as to be distributed to M pieces of antennas, radio signals arriving via transmission paths H are received via N antennas by a receiver **102**, and M transmission signals are obtained from N reception signals by signal processing, thereby obtaining received data.

[0006] The principle of the MIMO system will be described. When M transmission signal vectors distributed by the transmitter **101** are set as s=(s1, s2, . . . , sM), a signal is transmitted from a transmission antenna "i" is multiplied by hji and a resultant signal is received by a reception antenna "j", a reception signal xj by the receiving antenna "j" is expressed by the following expression (1).

$$xj=\{\Sigma(hji\times si)\}+vj\ (i=1\ to\ M) \tag{1}$$

[0007] where vj denotes noise which occurs at the reception antenna "j" in the receiver **102**. When a matrix H of N rows and M columns using hji as an element, reception signal vector x=(x1, x2, . . . , xN), and noise vector v=(v1, v2, . . . , vN) which occurs in the receiver **102** are used, the expression (1) can be expressed as the following expression (2).

$$x=Hs+v \tag{2}$$

[0008] When the propagation path matrix H and the noise vector v in the expression (2) are known, a transmission signal "s" can be obtained from the reception signal "x". However, the propagation state between the transmitter **101** and the receiver **102** changes according to time and a place of communication, so that the propagation path matrix H is not determined unconditionally. Consequently, a training signal is multiplexed on a transmission signal, the training signal is received by the receiver **102**, and an action matrix W for obtaining the transmission signal from the received signal is calculated. By obtaining the action matrix W, the state of the propagation path matrix H and the noise vector "v" is learned by training. By using the reception signal "x" which is received after the training period and the action matrix W, an estimation value s' of the transmission signal can be expressed by the following equation (3).

$$s'=W^{T}x \tag{3}$$

[0009] According to the MIMO system, data of an amount which is ideally larger by the number (M times) of transmission antennas as compared with the system of sending transmission data from a single antenna can be transmitted. Consequently, the MIMO system is expected as a system of a large communication capacity per a radio frequency band (high frequency use efficiency).

[0010] As shown in **FIG. 2A**, in the case where many buildings exist as in cities, radio signals from the transmitter **101** are reflected by many buildings and arrives at the receiver **102** via various paths. Such propagation paths will be called a multipath transmission environment. As shown in **FIG. 2B**, transmission paths in which no obstacles and buildings by which a signal is reflected exist between the transmitter **101** and the receiver **102** will be called an insight transmission environment. **FIG. 2C** is a graph showing the characteristics of the capacity of communication path and the number of transmission/reception antennas in the MIMO system with respect to the multipath transmission environment and the insight transmission environment. It is understood from **FIG. 2C** that the capacity of the communication path increases in proportional to increase in the number of transmission/reception antennas in the multipath transmission environment, whereas the capacity of the communication path in the insight transmission environment is smaller than that of the multipath transmission environment and, even when the number of transmission/reception antennas increases, the capacity of the communication path does not increase. In the example shown in **FIGS. 2A** to **2C**, when the number of transmission antennas of the transmitter **101** is 3 and the number of reception antennas of the receiver **102** is 3, reception signals x1, x2, and x3 can be expressed as the following expressions (4), (5), and (6), respectively.

$$x1=h11s1+h12s2+h13s3+v1 \tag{4}$$

$$x2=h21s1+h22s2+h23s3+v2 \tag{5}$$

$$x3=h31s1+h32s2+h33s3+v3 \tag{6}$$

[0011] In the multipath transmission environment, since a path from a transmission antenna **201***a* to a reception antenna **202***a* and a path from a transmission antenna **201***b* to the reception antenna **202***a* are different from each other, the elements h11 and h12 in the propagation path matrix have different values. On the other hand, in the insight transmission environment, as compared with the distance between the transmission antennas **201***a* and **201***b*, the distance between the transmission antenna **201***a* and the reception antenna **202***a* and the distance between the transmission antenna **201***b* and the reception antenna **202***a* are sufficiently longer. Consequently, the transmission antennas **201***a* and **201***b* seem to be almost in the same position from

the reception antenna **202a**, so that the propagation path matrix elements **h11** and **h12** have similar values. For a reason similar to the above, **h11** and **h13** have similar values, and **h11** and **h21** have similar values, so that it becomes difficult to separate the transmission signals **s1**, **s2** and **s3** from the expressions (4), (5), and (6).

[0012] Accordingly, it can be said that the MIMO system has the better communication path capacity characteristic in the multipath transmission environment as compared with the insight transmission environment. On the other hand, also in the insight transmission environment, it is desired to provide the MIMO system of a larger communication path capacity.

SUMMARY OF THE INVENTION

[0013] The invention has been achieved in such a background and its object is to provide a wireless transmission repeater system capable of assuring a communication path capacity even in the insight transmission environment in accordance with the MIMO communication system, and wireless equipment for use in the system.

[0014] To achieve the object, the invention provides an MIMO communication system, that is, a wireless transmission repeater system including a wireless device having a transmitter for distributing transmission data to a plurality of antennas, and transmitting the data as radio signals from the plurality of antennas, and a wireless device having a receiver for receiving the radio signals transmitted by a plurality of antennas and reproducing the transmission data, wherein a plurality of repeater stations are disposed between the wireless device having the transmitter and the wireless device having the receiver, and one of the wireless devices has relay judging means for judging whether the repeater station is used or not, and means for transmitting a control signal for driving the repeater station on the basis of the judgment.

[0015] In a preferred embodiment of the invention, the wireless devices are a mobile station and a base station such as a portable terminal in mobile communications.

[0016] When one of the wireless devices measures a reception power or a signal-to-noise ratio of a pilot signal periodically transmitted from the other wireless device and the reception power or the signal-to-noise ratio of the pilot signal is higher than a threshold value, the relay judging means notifies the other wireless device of a control signal indicative of a demand to start relaying by the repeater station. When the reception power or the signal-to-noise ratio of the pilot signal is equal to or lower than the threshold value, the relay judging means notifies the other wireless device of a control signal indicative of a demand to stop relaying by the repeater station.

[0017] Alternately, there is also the relay judging means such that when one of the wireless devices measures a signal-to-noise ratio of a pilot signal periodically transmitted from the other wireless device, estimates a propagation path from a training signal transmitted from the one of the wireless devices, and calculates a communication capacity from the signal-to-noise ratio and the estimation of the propagation path. When the communication capacity is larger than the threshold, the control signal indicative of a demand to start relay by the repeater station is notified to the other wireless device. When the communication capacity becomes equal to or lower than the threshold, the control signal indicative of a demand to stop relaying by the repeater station is notified to the other wireless device.

[0018] Modulation to data to be transmitted and a radio signal, demodulation of the data to be transmitted from a received radio signal, and a reproducing process are substantially the same as those performed by a wireless device according to a conventional MIMO communication system. Specifically, a transmission part has means for serial-to-parallel converting encoded transmission data and distributing the data to a plurality of antennas, means for multiplexing a training signal on the transmission data so that the distributed transmission data can be restored by a receiver, means for controlling a transmission timing, and a transmitter for transmitting the transmission data as radio signals from a plurality of antennas. A reception part has means for controlling a reception timing for receiving the radio signals by a plurality of antennas, means for restoring the transmission signals distributed to the plurality of antennas from the transmitter on the basis of the training signal multiplexed on the received radio signal, means for parallel-to-serial converting the transmission signals distributed to the plurality of antennas, thereby combining the transmission signals as encoded data, and means for performing an error correcting process on the encoded data, thereby obtaining reception data.

[0019] In a multi point wireless transmission repeater system according to the invention, by disposing repeaters between a transmitter of a transmission wireless device and a receiver of a reception wireless device, a propagation path from the transmitter to the repeater and a propagation path from the repeater to the receiver are independently established. Thus, by disposing repeaters at multiple points, a propagation path characteristic similar to the multipath transmission environment can be generated. Consequently, also in an insight transmission environment in which no obstacles and no buildings do not exist between and around the transmitter and the receiver and the transmitter and the receiver can see each other directly, by artificially creating the multipath transmission environment by introducing the repeaters and maintaining the excellent characteristic of the communication path capacity, when the number of transmission/reception antennas is increased, a characteristic similar to the multipath transmission environment can be achieved.

[0020] These and other objects, feature and advantages of the present invention will become more apparent in view of the following detailed description of the preferred embodiments in conjunction with accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] FIG. 1 is a diagram showing the configuration of a wireless transmission repeater system for explaining the principle of the MIMO system.

[0022] FIGS. 2A to 2C are diagrams for explaining the relation between a multipath transmission environment and a communication capacity characteristic of the MIMO system in mobile communications.

[0023] FIG. 3 is a block diagram showing the configuration of an embodiment of the wireless transmission repeater system according to the invention.

[0024] FIG. 4 is a configuration diagram of an embodiment of a mobile communication system using the wireless transmission repeater system according to the invention.

[0025] **FIG. 5** is a flowchart of operations performed at the start of wireless transmission between a mobile station and a base station in **FIG. 4**.

[0026] **FIGS. 6A and 6B** are flowcharts of operations performed when a multiple-point relay transmission in the invention is stopped.

[0027] **FIGS. 7A** to **7C** are diagrams each showing a message format of a control signal in an embodiment of a wireless transmission repeater system according to the invention.

[0028] **FIG. 8** is a flowchart for explaining relaying operation of a repeater station in the embodiment of the wireless transmission repeater system according to the invention.

[0029] **FIGS. 9A and 9B** are timing charts of transmission and reception at the time of the multiple-point relay transmission in the embodiment of the wireless transmission repeater system according to the invention.

[0030] **FIG. 10** is a block diagram showing the configuration of an example of a mobile station used in the wireless transmission repeater system according to the invention.

[0031] **FIGS. 11A and 11B** are diagrams for explaining a calculation part of transmission/reception timings in the mobile station of **FIG. 10**.

[0032] **FIG. 12** is a block diagram of an MIMO demodulator and a P/S converter in an example of the mobile station according to the invention.

[0033] **FIG. 13** is a block diagram of an S/P converter and an MIMO demodulator in an example of the mobile station according to the invention.

[0034] **FIG. 14** is a block diagram of a repeater judgment part in an example of the mobile station according to the invention.

[0035] **FIG. 15** is a block diagram showing the configuration of an example of a repeater station according to the invention.

[0036] **FIG. 16** is a timing chart for explaining repeater input/output timings in the repeater station of **FIG. 15**.

[0037] **FIG. 17** is a block diagram showing the configuration of an example of a base station according to the invention.

[0038] **FIG. 18** is a timing chart of a calculation part of transmission/reception timings in the base station of **FIG. 17**.

[0039] **FIG. 19** is a characteristic comparison diagram showing effects of the invention.

[0040] **FIG. 20** is a block diagram showing the configuration of another embodiment of a wireless transmission repeater system according to the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0041] Embodiments of the invention will be described hereinbelow with reference to the drawings.

[0042] **FIG. 3** is a block diagram showing the configuration of an embodiment of a wireless transmission repeater system according to the invention. The wireless transmission repeater system is constructed by: a first wireless device having a transmitter **101** for performing an encoding process for adding redundancy to transmission data so that an error of a wireless communication path can be corrected and transmitting encoded data so as to be distributed as signals s1, s2, . . . , and sM in correspondence with a plurality (M) of antennas; a plurality of second wireless devices **301***a*, **301***b*, and **301***c* having a plurality of repeaters for relaying the radio signals transmitted from the plurality of antennas; and a third wireless device having a receiver **102** for receiving the relayed radio signals by a plurality (N) of antennas and obtaining received data.

[0043] The signals s1, s2, . . . , and sM are stored as z1, z2, . . . , and zL in buffers of the repeaters **301***a*, **301***b*, and **301***c*, respectively. When a matrix indicative of the characteristic of the transmission path between the transmitter **101** and the repeaters **301***a*, **301***b*, and **301***c* is set as a propagation path F, the signals z1, z2, . . . , and zL stored in the repeaters **301***a*, **301***b*, and **301***c* can be expressed by the following expression (7) obtained from the expression (2).

$$z=Fs+v' \tag{7}$$

[0044] where v' denotes noise which occurs in the repeaters **301***a*, **301***b*, and **301***c*. The signals z1, z2, . . . , and zL stored in the repeaters **301a**, **301***b*, and **301c** are delayed by predetermined time by the buffers and transmitted to the receiver **102**. When a matrix expressing the characteristic of the propagation paths between the repeaters **301***a*, **301***b*, and **301***c* and the receiver **102** is a propagation path G, the signals x1, x2, . . . , and xN received by the receiver **102** can be expressed by the following expression (8) derived from the expressions (2) and (7).

$$x=Gz+v''=GFs+Gv'+v'' \tag{8}$$

[0045] where v'' denotes noise which occurs in the receiver **102**. In order to algebraically obtain the signals s1, s2, . . . , and sM transmitted by the transmitter **101** from the expression (8), a known training signal is multiplexed on the transmission data, and the resultant is transmitted, thereby enabling a matrix W for obtaining the transmission signals s1, s2, . . . , and sM from the reception signals x1, x2, . . . , and xN to be derived by using the SMI (Sampled Matrix Inverse) method of an MMSE (Minimum Mean Square Error) which will be described hereinlater. After the matrix W is obtained, signals s1', s2', . . . , and sM' obtained by restoring the signals distributed to the M antennas by the transmitter **101** can be calculated by the following expression (9).

$$s'=W^Tx \tag{9}$$

[0046] The signals s1', s2', . . . , and sM' of the M transmission antennas obtained by the expression (9) are combined, and the combined data is subjected to an error correction decoding process, thereby enabling the reception data and transmission data to be reproduced.

[0047] **FIG. 4** is a diagram showing the configuration of an example of a mobile communication system using the wireless transmission repeater system according to the invention. Data transmitted from a transmitter **101***b* of a mobile station **408** is received by a receiver **102***a* of a base station **406** via the repeaters **301***a*, **301***b*, and **301***c* of repeater stations **407***a*, **407***b*, and **407***c*, and sent to a control station **405** for controlling the base station **406**. By an application of the mobile station **408**, the data sent to the

control station 405 is transmitted to another mobile station via a cellular network 404 and used for speech communication or the data is connected to the Internet 402 via a gateway equipment 403 for connecting the cellular network 404 and the Internet 402, transmitted to a server 401 on the Internet, and can be used to request a service provided by the server 401. The data transmitted from the server 401 to the mobile station 408 is transmitted to the base station 406 via the Internet 402, gateway equipment 403, cellular network 404, and control station 405. Further, the data transmitted from the transmitter 101*a* of the base station 406 is received by the receiver 102*b* of the mobile station 408 via the repeaters 301*a*, 301*b*, and 301*c* of the repeater stations 407*a*, 407*b*, and 407*c*. A device serving as the repeater station may be a fixed facility of an exchange carrier or a user terminal having a speech function and a relaying function.

[0048] FIG. 5 is a flowchart of operations at the start of wireless transmission between the mobile station and the base station in FIG. 4. A state where communication is carried out between the mobile station 408 and the base station 406 without using the repeater stations 407*a* and 407*b* will be called a state where the repeaters do not act. In the state where the repeaters do not act, the mobile station 408 determines whether relaying operation is to be performed or not.

[0049] According to a first method of the determination, a pilot signal is periodically transmitted from the base station 406, and the signal-to-noise (S/N) ratio of the pilot signal received by the mobile station 408 is measured. When the S/N ratio exceeds a threshold, the pilot signal from the base station is sufficiently large. Consequently, it is determined that the transmission path is the insight transmission path, and start of relay is determined.

[0050] According to a second method of the determination, a received power is used in place of the S/N ratio.

[0051] According to a third method of the determination, the pilot signal from the base station 406 and the training signal are periodically transmitted at predetermined timings. The capacity of a communication path is calculated by estimating a propagation path on the basis of the training signal, and the capacity of the communication path is compared with the threshold. When it is determined that the characteristic of the communication path capacity becomes better by relaying the signal, start of relaying is determined.

[0052] In the case where the start of relay is determined, a control signal indicative of a relay start demand is sent from the mobile station 408 to the base station 406. On receipt of the control signal indicative of the relay start demand, the base station 406 determines whether the number N of repeaters managed by the base station 406 satisfies the minimum number (threshold M) of repeaters required by the replay start demand or not. If it is satisfied, a control signal of relay operation directions for notifying of start of relay is transmitted to the repeater station and the mobile station. If the number N of repeater stations does not satisfy the threshold M, the base station 406 does not transmit the control signal of relay operation directions and discards the relay start demand from the mobile station 408. The mobile station 408 and the repeater stations 407*a* and 407*b* which have received the relay operation directions perform transmission/reception of data at timings designated by the relay operation directions.

[0053] When data is received from the mobile station 408 or the base station 406, the repeater stations 407*a*, 407*b*, and 407*c* store the data in the buffers so as to be delayed by predetermined time and transmit the delayed data. First, whether the data stored in the buffer is to be transmitted or not is determined by a method of measuring the reception power of the pilot signal periodically transmitted from the base station 406, if the received power is lower than the threshold, it is far from the base station 406. Consequently, it is determined that relaying operation produces a little effect, so that the data is not transmitted. When the reception power of the signal received from the transmitting station (mobile station 408 or base station 406) is lower than the threshold, the distance from the transmitting station is long. Consequently, it is determined that relaying operation produces little effect, and the data is not transmitted. FIG. 5 shows an example in which whether a signal Data_D(1) transmitted from the base station 406 is transmitted or not is determined by the repeater station 407*a* and, as a result of the determination, the signal is not transmitted to the mobile station 408.

[0054] FIGS. 6A and 6B are flowcharts of operations of the case where the base station takes the initiative and the case where the mobile station takes the initiative to stop multi-point relay transmission in an embodiment of the wireless transmission repeater system according to the invention.

[0055] (a) the case where the base station takes the initiative

[0056] When the repeater station 407*a* is a user terminal having a relay function, a hand-over for switching a base station to an adjacent base station as the repeater station 407*a* moves may occur. At the time of performing the hand-over, control signals are transmitted between the repeater station 407*a* and the base station 406, so the base station 406 can grasp increase or decrease in the number of repeater stations. Therefore, when the number N of repeater stations cannot satisfy the number (threshold L) of repeater stations necessary for the relaying operation, a control signal of relay operation directions indicative of stop of relay is transmitted from the base station 406. The mobile station 408 and relay stations 407*a* and 407*b* which have received the control signal stop the relaying operation and perform communication directly between the mobile station 408 and the base station 406.

[0057] (b) the case where the mobile station takes the initiative

[0058] When the relay determination is made by the mobile station 408 during the relaying operation and relay stop is determined, a control signal of relay stop demand is transmitted to the base station 406. The relay determination is made in such a manner that the S/N ratio or reception power of the pilot signal of the base station 406 is measured. When the S/N ratio or reception power becomes equal to or lower than the threshold, it is regarded that transmission environment with the base station 406 has changed from the insight transmission environment and relay stop is determined. In another method, a propagation path is estimated from the training signal, the S/N ratio is obtained from the pilot signal of the base station 406, and the capacity of the communication path is calculated on the basis of the result of estimation of the transmission path and the S/N ratio.

When the capacity of the communication path becomes equal to or smaller than the threshold, it is regarded that there is no effect produced by relay transmission, and the relay stop is determined. When the relay stop demand is received from the mobile station **408**, the base station **406** stops the relaying operation by issuing a control signal of relay operation directions indicative of relay stop to the repeater stations **407***a* and **407***b* and the mobile station **408**.

[0059] FIGS. 7A to 7C show the formats of messages of control signals in the embodiment of the wireless transmission repeater system according to the invention. **FIG. 7A** shows the format of a control signal of relay start demand or relay stop demand from the mobile station **408** to the base station **406**. LEN indicates the number of words when one word consists of 32 bits, MSG indicates the type of the control signal, and Opr denotes the direction of the path for relaying which is either the direction (uplink) from the mobile station **408** to the base station **406**, the direction (downlink) from the base station **406** to the mobile station **408**, or two-way. Num_M (threshold M) is used to determine start of relay when the number of repeater stations managed by the base station **406** is larger than Num_M. Num_L (threshold L) is used to determine stop of relay when the number of repeater stations is smaller than Num_L.

[0060] **FIG. 7B** shows the format of start of relay of relay operation directions from the base station **406** to the mobile station **408** and repeater stations **407***a*, **407***b*, and **407***c* and updating of parameters. UID indicates the ID number of each of the mobile station **408** and repeater stations **407***a*, **407***b*, and **407***c*. DST and DLEN specify the transmission timings of the base station **406** as shown in **FIG. 9A** in the direction (downlink) from the base station **406** to the mobile station **408**. UST and ULEN specify the transmission timings of the mobile station **408** as shown in **FIG. 9B** in the direction (uplink) from the mobile station **408** to the base station **406**. RXL is used to determine whether data to be relayed by the repeater stations **407***a*, **407***b*, and **407***c* is transmitted or not. When the reception power of the relay data is lower than RXL, the data is not relayed. TXL is used to determine whether data to be relayed by the repeater stations **407***a*, **407***b*, and **407***c* is transmitted or not. If the reception power of the pilot signal which is periodically sent from the base station is lower than TXL, the data is not relayed. GAIN_K is used to specify how many times the transmission power is higher than the received power of the data to be relayed by the repeater stations **407***a*, **407***b*, and **407***c*.

[0061] **FIG. 7C** is a format diagram showing stop of relay in the relay operation directions from the base station **406** to the mobile station **408** and repeater stations **407***a*, **407***b*, and **407***c* in the embodiment.

[0062] **FIG. 8** is a flowchart for explaining the relaying operation of the repeater station in the embodiment of the wireless transmission repeater system according to the invention. In the state where repeater does not act (step S1), when the control signal indicative of relay operation directions is received from the base station (S2), if the direction is start of relay, the system enters the state where the repeater acts. If the direction is stop of relay or updating of parameters, the system continues while remaining in the state where the repeater does not act (S3). In the case where the system enters the state where the repeater acts (S4), when relay data is received (S5), the data is stored in the buffer and whether the data is to be transmitted or not is determined (S6). Whether the data is transmitted or not is determined as follows. When the reception power of the relay data is higher than the threshold RXL designated by the control signal of the relay operation direction and when the reception power of the pilot signal periodically transmitted from the base station **406** is higher than the threshold TXL designated by the control signal of the relay operation direction, the data is transmitted (S7). In the other cases, the relay data is discarded (S8) for the reason that when the wireless transmission environment from the mobile station **408** or base station **406** is bad or the distance is long, the repeater station **407***a* determines by itself that the data should not be relayed. When transmission of the data is determined, the data is read from the buffer at a timing designated by the control signal of the relay operation directions and transmitted. In the case where the control signal of the relay operation directions is received in the relaying state (S9), the direction is determined (S10). If the direction is stop of relay, the system enters the state where the repeater does not act. If the direction is updating of parameters (S11), the relay operation parameters such as the transmission timing are updated (S12), and the relay state is maintained. If the direction is start of relay, the relay state is just maintained.

[0063] **FIGS. 9A and 9B** are diagrams showing transmission and reception timings at the time of multi point transmission in the embodiment of the wireless transmission repeater system according to the invention. In the direction (downlink) from the base station **406** to the mobile station **408**, by using the pilot signal periodically sent from the base station **406** as a reference, a transmission signal is sent from the base station **406** at a timing deviated only by DST specified by the control signal of the relay operation directions. On the transmission signal, the training signal necessary to obtain the signal distributed by the base station **406** to the plurality of antennas by the mobile station **408** in accordance with the MIMO system and data of a user application are multiplexed. The transmission signal is transmitted for the period of DLEN specified by the control signal of the relay operation directions.

[0064] When the repeater stations **407***a* and **407***b* receive the transmission signal from the base station **406**, the repeater stations **407***a* and **407***b* transmit the signal to the mobile station **408** at a timing delayed only by DLEN. In the mobile station **408**, by synthesizing a reception signal received as a direct wave from the base station **406** and a reception signal received via the repeater stations **407***a* and **407***b*, reception data is restored in accordance with the MIMO system. In the direction (uplink) from the mobile station **408** to the base station **406**, the transmission signal is sent from the mobile station **408** at a timing deviated from the pilot signal periodically transmitted from the base station **406** as a reference only by UST specified by the control signal of the relay operation directions. On the transmission signal, the training signal necessary to obtain the signal distributed to the plurality of antennas by the mobile station **406** by the base station **406** in accordance with the MIMO system and data of the user application are multiplexed.

[0065] The transmission signal is transmitted continuously for the period of ULEN specified by the control signal of the relay operation directions. The repeater stations **407***a* and **407***b* receive the transmission signal from the mobile station

408 and transmit the transmission signal to the base station 406 at a timing delayed only by ULEN. In the base station 406, by synthesizing the reception signal received as a direct wave from the mobile station 408 and the reception signal received via the repeater stations 407a and 407b, the reception data is restored in accordance with the MIMO system.

[0066] FIG. 10 is a block diagram showing the configuration of an example of the mobile station used in the wireless transmission repeater system according to the invention. The mobile station 408 is constructed by: a plurality of antennas 1001a, 1001b, and 1001c for transmitting/receiving a radio signal in a radio area; a radio frequency part 1002 for performing a filtering process on reception signals from the antennas 1001a, 1001b, and 1001c, an A/D converting process of converting an analog signal into a digital signal, a D/A converting process for converting transmission signals as digital signals sent to the antennas 1001a, 1001b, and 1001c to analog signals, a filtering process, and power amplification; a modem part 1006 having the functions of restoring the transmission signals distributed by the base station 406 to the plurality of antennas from the reception signals from the radio frequency part 1002, performing an error correcting process to obtain a reception signal, performing an encoding process for adding redundancy to the transmission signal to the radio frequency part 1002 so that error correction can be made, distributing the signals to the plurality of antennas 1001a, 1001b, and 1001c, and multiplexing the training signals to restore the signals by the base station 406; a control part 1016 for extracting a control signal from the signal received from the modem part 1006, performing a protocol process regarding call connection or relay operation, and controlling transmission/reception timings at the time of relay; and a speech part 1021 for outputting the signal received by the control part 1016 to a speaker in accordance with an external input/output interface, multiplexing an input signal from an external input/output device such as a microphone onto the control signal of the control part, and transmitting the resultant signal to the model part 1006. Each of the blocks will be described in detail in accordance with the flow of signals.

[0067] The radio signals received by the antennas 1001a, 1001b, and 1001c are distributed to RF receivers 1004a, 1004b, and 1004c by circulators 1003a, 1003b, and 1003c in the radio frequency part 1002. In the RF receivers 1004a, 1004b, and 1004c, the filtering process is performed on the reception signal so that the band is changed to a base band signal process band, the analog signal is converted to a digital signal (A/D conversion), and the digital signal is transmitted to the modem part 1006. In the modem part 1006, the reception signal is separated by a signal separator 1007 into a pilot signal of the base station and a data signal of the base station. In a searcher 1008 for a transceiver timing of the base station, by adding the same phase of the pilot signal of the base station, the timing of transmitting the pilot signal can be detected. In a repeater judgment part 1009, whether a relay operation is performed or not is judged. As a method of judging the relay operation, a method of determining the relay operation by comparing the S/N ratio of the pilot signal of the base station with the threshold or calculating the capacity of the communication path on the basis of the result of presumption of the propagation path of the base station signal and the S/N ratio of the pilot signal, and comparing the capacity with the threshold can be mentioned. When a trigger of start or stop of relay is generated by the repeater judgment part 1009, it is notified to a protocol processing part 1019 in the control part 1016, and a control signal of relay start demand or relay stop demand is transmitted from the mobile station 408 to the base station 406. The receiver 102 includes: an MIMO demodulator 1010 for calculating transmission signals s1', s2', . . . and sM' of the base station from the reception signals x1, x2, . . . , and xN of the base station in accordance with the MIMO system, a P/S converter 1011 for parallel-to-serial converting the transmission signal of the base station to thereby obtaining encoded data; and an error correction decoder 1012 for performing a decoding process by executing an error correction on the encoded data. The decoded reception data is separated by a separator 1018 in the control part 1016 into a control signal and data. The control signal is used for a protocol process necessary for call connection in the protocol processing part 1019 and as a control signal necessary for the invention. A control signal of relay operation directions from the base station 406 is stored as relay operation directions parameters 1020. A calculator part 1017 of transceiver timings generates timing signals (relay mode: MODE, direct wave: DR_EN, and repeater station wave: RP_EN) and a timing signal (transmission enable: TX_EN) necessary for an MIMO modulator 1013 on the basis of the pilot signal timing detected by the searcher 1008 of transceiver timing of the base station and the transmission/reception timings specified by the relay operation directions parameters 1020.

[0068] In the speech part 1021, data obtained from the separator 1018 is supplied to a coding block 1023 where, for example, sound encoded data is converted to a signal adapted to the interface of an external input and output 1024, and the resultant data is output from the external input and output 1024 via a speaker or the like. Data received from a microphone or the like is subjected to a sound encoding process by the coding block 1023 via the external input and output 1024. A multiplexer 1022 multiplexes a control signal from the protocol processing part 1019 and data from the coding block 1023 as transmission data. The multiplexed transmission data is passed to the transmitter 101.

[0069] In the transmitter 101, the transmission data is converted to encoded data on which a redundancy signal is added for error correction by an error correction encoder 1015. The encoded data is subjected to serial-to-parallel conversion by an S/P converter 1014 so that the transmission data is distributed to the plurality of transmission antennas. The training signal is multiplexed on the transmission data by the MIMO modulator 1013, and the resultant data is transmitted to RF transmitters 1005a, 1005b, and 1005c in the radio frequency part 1002. The RF transmitters 1005a, 1005b, and 1005c convert a digital signal into an analog signal (D/A conversion), performs power amplification and a filtering process, and transmits the transmission data as radio signals from the antennas 1001a, 1001b, and 1001c via the circulators 1003a, 1003b, and 1003c.

[0070] FIGS. 11A and 11B are timing charts of the calculator part 1017 of transceiver timings in the mobile station 408. FIG. 11A shows operations in the case where the repeaters do not act, and the pilot signal and the base station signal are transmitted from the base station 406. A relay mode (MODE) becomes a fixed output at a low level indicative of the state where repeaters do not act. The direct

wave (DR_EN) from the base station **406** becomes a low-level output in the interval of the pilot signal and becomes a high-level output in the interval of the base station signal. A wave (RP_EN) via the repeater station as an indirect wave from the repeater stations **407***a*, **407***b*, and **407***c* is an output fixed at the low-level. A transmission timing (TX_EN) of the mobile station **408** becomes a low-level output in the interval of the pilot signal, and a high-level output in the interval of the transmission of the mobile station. **FIG. 11B** shows operations in the state where the repeaters act. The relay mode (MODE) becomes an output fixed at the high level indicative of relay. The direct wave (DR_EN) from the base station **406** becomes a high-level output from a timing deviated from the pilot signal as a reference by DST specified by the relay operation directions parameters **1020**, for the interval of DLEN similarly specified by the relay operation directions parameters **1020**. The direct wave (DR_EN) becomes a low-level output for the interval of the next DLEN. The direct wave alternately becomes the high level and low level until the interval of the next pilot signal.

[0071] The wave (RP_EN) via the repeater station as an indirect wave from each of the repeater stations **407***a*, **407***b*, and **407***c* becomes a high-level output in the interval when the DR_EN is at the low level for the interval of DLEN and becomes a low-level output in the other period. The transmission timing (TX_EN) of the mobile station **408** becomes a high-level output from a timing deviated from the pilot signal as a reference by UST specified by the relay operation directions parameters **1020**, for the interval of ULEN similarly specified by the relay operation directions parameters **1020**. The transmission timing goes low for the interval of the next ULEN and alternately becomes the high and low levels until the interval of the next pilot signal.

[0072] **FIG. 12** is a block diagram showing the configuration of the MIMO demodulator **1010** and the P/S converter **1011** in the mobile station. Although **FIG. 12** illustrates the configuration in the mobile station, the configuration of the MIMO demodulator and P/S converter in a base station is the same. The outline of operations will be described hereinbelow. The base station signal separated by the signal separator **1007** is transmitted to prior processing units **1216***a*, **1216***b*, and **1216***c* of the MIMO demodulator **1010**. The configurations and operations of the prior processing units **1216***a*, **1216***b*, and **1216***c* are the same. At the time of relay, the base station signal processed by a demultiplexer **1217**, a buffer **1218**, and an adder **1219** is selected by a selector **1220**. At the other times, the base station signal is selected. The detailed operations of the demultiplexer **1217**, buffer **1218**, and adder **1219** will be described later. The signal sent to the demultiplexer **1221** is separated by the demultiplexer **1221** into the training signal and data. The training signal is sent to weight calculation blocks **1212***a*, **1212***b*, and **1212***c* and the data is transmitted to multiply-add calculation parts **1211***a*, **1211***b*, and **1211***c*. By the weight calculation block **1212***a* and multiply-add calculation part **1211***a*, a process of obtaining an estimation value s'**1** of data transmitted from the first transmission antenna is performed. In the weight calculation block **1212***a*, weights W11, W21, and W31 for removing components transmitted from the transmission antennas other than the first transmission antenna are calculated. By using the weights, multiply-add calculation is executed by the multiply-add calculation part **1211***a*, thereby obtaining the estimation value s'**1** of the data transmitted from the first antenna. Similarly, an estimation value s'**2** of data transmitted from the second transmission antenna is calculated by the weight calculation block **1212***b* and multiply-add calculation part **1211***b*. An estimation value s'**3** of data transmitted from the third transmission antenna is calculated by the weight calculation block **1212***c* and multiply-add calculation part **1211***c*.

[0073] The estimation values s'**1**, s'**2**, and s'**3** are demodulated by demodulators **1215***a*, **1215***b*, and **1215***c*, respectively, converted to serial data by the P/S converter **1011**, and the serial data is sent to the error correction decoder **1012**. The details of the weight calculation blocks **1212***a*, **1212***b*, and **1212***c* and multiply-add calculation parts **1211***a*, **1211***b*, and **1211***c* will be described. In the weight calculation block **1212***a* and multiply-add calculation part **1211***a*, the signal from the first transmission antenna is regarded as a desired wave, the signals from the transmission antennas other than the first transmission antenna are regarded as interference waves, and by applying an interference wave removing algorithm used by an adaptive array antenna, a signal from the first transmission antenna is estimated. Signals from the other transmission antennas are estimated in a similar manner. For example, in the case of using the SMI (Sampled Matrix Inverse) method in the MMSE (Minimum Mean Square Error), a weight can be obtained by calculating the following by the weight calculation blocks **1212***a*, **1212***b*, and **1212***c*.

$$R_{\hat{x}\hat{x}}=E[\hat{x}^*\hat{x}^T] \tag{10}$$

$$r_{\hat{x}\hat{s}}^{(m)}=E[\hat{x}^*\hat{s}_m] \tag{11}$$

$$w_m=R_{\hat{x}\hat{x}}^{-1}r_{\hat{x}\hat{s}}^{(m)} \tag{12}$$

[0074] By calculating the following in the multiply-add calculation parts **1211***a*, **1211***b*, and **1211***c*, the estimation values s'**1**, s'**2**, and s'**3** can be obtained.

$$s_m'=w_m^T x \tag{13}$$

[0075] where

[0076] M: the number of transmission antennas

[0077] N: the number of reception antennas

[0078] $\hat{s}_m$: the value of training signal transmitted from the m-th transmission antenna

[0079] s_m: the value of data transmitted from the m-th transmission antenna

[0080] $\hat{s}$: vector of the M-th order given by $\hat{s}=(\hat{s}_1, \ldots, \hat{s}_M)^T$

[0081] s: vector of the M-th order given by $s=(s_1, \ldots, s_M)^T$

[0082] $\hat{x}_n$: n-th reception antenna received value (reception value for the training signal)

[0083] x_n: n-th reception antenna received value (reception value for data)

[0084] $\hat{x}$: vector of the N-th order given by $\hat{x}=(\hat{x}_1, \ldots, \hat{x}_N)^T$

[0085] x: vector of the N-th order given by $x=(x_1, \ldots, x_N)^T$

[0086] $R_{\hat{x}\hat{x}}$: correlation matrix (NXN) of the received vector $\hat{x}$ of training signal

[0087] $r^{(m)}_{\hat{x}\hat{s}}$: correlation vector (of the N-th order) of $\hat{x}$ and $\hat{s}_m$

[0088] w_m: weight vector (of the N-th order) for obtaining data from the m-th transmission antenna. $w_m=(w_{1m}, \ldots, w_{Nm})^T$

[0089] $(\cdot)^*$ denotes complex conjugate and $(\cdot)^T$ denotes transposition.

[0090] The operations of the demultiplexer **1217**, buffer **1218**, and adder **1219** at the time of relay will be described. The base station signal is separated by the demultiplexer **1217** into a base station signal (refer to **FIG. 9**, called a direct wave signal hereinlater) directly received from the antenna of the base station and a base station signal (hereinlater, called relay wave signal) transmitted after being delayed by the amount of DLEN in **FIG. 9** by being once stored in the buffer **1218** and added to the relay wave signal by the adder **1219**. By the processes of delay and addition, the signal transmitted from the antenna of the base station can be regarded as a signal which propagates through a propagation path obtained by synthesizing the propagation path in the state where the repeaters do not act and the propagation path in the state where the repeaters act and reaches the mobile station. Since it can be expected that the synthesized propagation path is closer to the multipath transmission environment, improvement in the capacity of the communication path can be expected. However, when the direct wave signal is much stronger than the relay wave signal, it becomes equivalent to the case where the relaying method is not used. In such a case, the adder **1219** is changed to a weighted adder to adjust the weight so that the ratio between the direct wave signal and the relay wave signal becomes proper.

[0091] **FIG. 13** is a block diagram showing the configuration of the S/P converter **1014** and the MIMO converter **1013** in the mobile station. Although **FIG. 13** is used to explain the mobile station, the S/P converter and the MIMO modulator in the base station have the same configuration. The outline of the operation will be described. Data encoded by the error correction encoder **1015** is converted by the S/P converter **1022** to parallel data having a width corresponding to the number of transmission antennas. A training signal generator **1303** generates a training signal used to separate data transmitted from each transmission antenna on the reception side and to estimate the propagation path. The parallel data and the training signal are time-division multiplexed by a multiplexer **1302**. The time division is performed at predetermined timings by using the rising edge of the TX_EN signal as a reference (**FIG. 11**). The time-division multiplexed signals are modulated by modulators **1304** into complex baseband signals **s1**, **s2**, and **s3** which are transmitted from the antenna via the radio frequency part **1002**. The training signal generated by the training signal generator **1303** will be described. To enable data to be separated on the reception side, the training signals transmitted from the antennas have to have a property of low cross-correlation. To enable the propagation path to be presumed, the autocorrelation function of the training signal has to be a delta function. For example, when the M series as a preferred pair is set as a training signal, the property is approximately satisfied.

[0092] **FIG. 14** is a block diagram showing the configuration of the repeater judgment part **1009**. The repeater judgment part **1009** is a circuit for judging whether relay is performed or not. **FIG. 14** shows two kinds of examples of judgment based on the S/N ratio of a received signal, and judgment based on the communication path capacity. A selector **1407** selects one of the methods.

[0093] First, in judgment based on the S/N ratio of a received signal, the fact that the S/N ratio of a received signal in the insight transmission environment is much higher than that of a received signal in the multipath transmission environment is used. The S/N ratio of the received signal measured by an S/N ratio measurement part **1403** by using the pilot signal of the base station is compared with a predetermined threshold S/N ratio by a comparator **1405**. When the S/N ratio of the received signal is higher than the threshold, "start of relay" is output from the comparator **1405** and the signal TR_EN goes high. When the S/N ratio of the received signal is lower than the threshold, "stop of relay" is output and the signal TR_EN goes low.

[0094] In judgment based on the communication path capacity, the fact that the communication path capacity in the insight transmission environment is smaller than that in the multipath transmission environment is used. The training signal of a signal directly received (not relayed) by the mobile station from the base station among the base station signals is extracted by a training signal separator **1401**. By using the training signal, the matrix H of a propagation way between the base station and the mobile station is presumed by a propagation way presumption part **1402**. For the propagation way presumption, for example, a pulse compressing method (Shuichi Sasaoka, "Wave Summit Course, Mobile Communications", Ohmsha, pp. 47 to 48, ISBN4-274-07861-2) is used. The communication path capacity in the state where repeaters do not act is estimated by a calculation part **1404** of the communication path capacity by using the matrix H of the propagation way and the S/N ratio of the received signal. The presumed communication path capacity is compared with the predetermined threshold communication way capacity by a comparator **1046**. When the presumed value is smaller, "start of relay" is output from the comparator **1406** and the signal TR_EN goes high. When the presumed value is larger than the threshold, "stop of relay" is output and the signal TR_EN goes low.

[0095] The details of the calculation part **1404** of the communication path capacity will be described. The communication path capacity C in the MIMO system is given as follows (F. R. Farrokhi, et al., "Link-Optimal Space-Time Processing with Multiple Transmit and Receive Antennas", IEEE Communications Letters, Vol. 5, NO. 3, March 2001).

$$C = \log_2 \det\left(I_N + \frac{P}{M\sigma^2} HH^*\right) \tag{14}$$

[0096] where

[0097] Pm: average transmission power of the m-th transmission antenna

[0098] P: entire transmission power

$$P = \sum_{m=1}^{M} P_m$$

[0099] Q: average noise power added to each reception antenna

[0100] I_N: unit matrix of the N-th order

[0101] H: matrix (N×M) of propagation way between transmitter and receiver

[0102] C: communication path capacity [bits/Hz] per bandwidth

[0103] $(\cdot)^H$ denotes complex conjugate transposition.

[0104] By using the S/N ratio of the received signal and the presumed propagation way matrix, the communication path capacity is calculated by the expression (14).

[0105] **FIG. 15** is a block diagram showing the configuration of an example of a repeater station according to the invention. The repeater station **407a** is constructed by: an antenna **1501** for transmitting/receiving a radio signal in an radio area; a radio frequency part **1502** for performing a filtering process on a signal received from the antenna **1501**, an A/D converting process of converting an analog signal to a digital signal, a D/A converting process of converting a digital transmission signal to the antenna **1501** to an analog signal, a filtering process, and power amplification; a modem part **1506** having a repeater for storing a signal received from the radio frequency part **1502** into a buffer, delaying the signal by predetermined time, and relaying the delayed signal, and having the function of performing demodulation and error correcting process for transmitting/receiving a control signal for relay to thereby obtain a reception signal, performing an encoding process of adding redundancy to the transmission signal to the radio frequency part **1002** so that error correction can be made, and modulating the signal; a control part **1517** for extracting the control signal from the reception signal obtained from the modem part **1506**, performing a protocol process related to call connection or relay operation, and controlling the transmitting/receiving timing at the time of relay; and a speech part **1526** for outputting the signal received by the control part **1517** as a sound signal to a speaker so as to be adapted to an external input/output interface, multiplexing an input signal from an external input/output such as a microphone on the control signal of the control part, and transmitting the resultant to the modem part **1506**.

[0106] The repeater station **407** has the configuration capable of not only processing a signal to be relayed but also multiplexing the control signal and data transmitted/received by the repeater station **407**. The repeater station **407a** may be a device having a plurality of antennas and performing MIMO demodulation and MIMO modulation. In the example, the repeater station does not perform a process according to the MIMO system, and it is assumed that the control signal to the repeater station is communicated by a radio signal which is not subjected to the MIMO modulation. Each of the blocks will be described in detail in accordance with the flow of a signal.

[0107] The radio signal received by the antenna **1501** is transmitted to a receiver **1504** via a circulator **1503** of a radio frequency part **1502**. The receiver **1504** performs a filtering process on the received signal so that the bandwidth is converted to a base band signal processing bandwidth, converts an analog signal to a digital signal (A/D conversion), and transmits the digital signal to the modem part **1506**. In the model part **1506**, the reception signal is separated by a separator **1507** into the base station pilot signal and the transmission station signal. In a searcher **1512**, by adding the same phase of the pilot signal of the base station, the timing of transmitting the pilot signal is detected.

[0108] The transmission station signal is stored in the buffer by the repeater **301**, the relay and transmission timings are controlled by the reception enable (RX_EN) and transmission enable (TX_EN) obtained by the transmission timing calculation part in the control part **1517** and relay enable (TR_EN) obtained by a repeater judgment part **1522**, and the transmission signal is set to a transmission power value obtained from a calculation part **1525** of transmission power and transmitted. To generate the signal, the transmission station signal separated by the separator **1507** is subjected to a demodulating process for demodulating a modulated signal by a demodulator **1508**, and the demodulated signal is subjected to error correction and a decoding process by an error correction decoder **1515**, thereby obtaining reception data. The reception data is separated by a separator **1518** in the control part **1517** into a control signal and data of the user application. The control signal is subjected to a call connection processing sequence or relay operation directions of the invention by a protocol processing part **1521**. The control signal of the relay operation directions is stored as relay operation directions parameters **1523**.

[0109] A received signal level measurement part **1513** measures a reception power of a base station pilot signal. If the reception power is higher than a threshold TXL of the relay operation directions parameters **1523** in a comparator **1519**, relaying operation is performed. If not, the repeater judgment part **1522** determines that relaying operation is not performed. Similarly, the received signal level measurement part **1514** measures a reception power of the transmission station signal. If the reception power is higher than a threshold RXL of the relay operation directions parameters **1523** in a comparator **1520**, relaying operation is performed. If not, the repeater judgment part **1522** determines that relaying operation is not performed. The calculation part **1525** of transmission power calculates a set value of transmission power by a value which is obtained by multiplying the reception power of the transmission station signal of the received signal level measurement part **1514** by "GAIN_K" times of the relay operation directions parameters **1523**.

[0110] In the speech part **1526**, the data separated by the separator **1518** is subjected to signal conversion adapted to the interface of an external input and output **1529** via a coding block **1528**, and sound is output from a speaker or the like. A sound input signal from a microphone or the like is subjected to an information source coding process by the coding block **1528** via the external input and output **1529**. In a multiplexer **1527**, a control signal from the protocol processing part **1521** and data from the coding block **1528** are multiplexed, and the resultant data is transmitted to an error correction encoder **1516** of the modem part **1506**.

[0111] The error correction encoder 1516 performs an encoding process for adding redundancy for performing error correction, and a modulating process according to the wireless transmission system is performed by a modulator 1511. A multiplexer 1510 multiplexes relay data from the repeater 301 and a modulated signal from the modulator 1511, and passes the multiplexed signal to an RF transmitter 1505 of the RF part 1502. The RF transmitter 1505 converts a digital signal to an analog signal (D/A conversion), performs power amplification and a filtering process, and transmits the transmission data as an RF signal from the antenna 1501 via the circulator 1503.

[0112] The repeater station can be constructed as a device dedicated to the MIMO communication system or as a wireless device having an RF transmission/reception part used for an RF communication which does not conform with the MIMO communication system.

[0113] FIG. 16 is a timing chart for explaining input/output timings of the repeater 301 in the repeater station 407. In the chart, relay in the direction (downlink) from the base station 406 to the mobile station 408 will be described as an example. In a calculation part 1524 of transmission timing, a received enable signal (RX_EN) becomes a high-level output for the period of DLEN which is specified by the relay operation directions parameters 1523 from a timing deviated from the reference of the pilot signal periodically transmitted from the base station 406, which is detected by the searcher 1512 by DST specified by the relay operation directions parameters 1523, and becomes a low-level output for the period of the following DLEN. For the period up to the next pilot signal, the high level and the low level are alternately repeated for the duration of DLEN. The transmission enable (TX_EN) signal repeats the high and low levels for the duration of DLEN at timings delayed from the reception enable (RX_EN) signal by DLEN. A signal supplied to the repeater 301 is stored in the buffer at the timing when the reception enable (RX_EN) is at a high-level output. When the transmission enable (TX_EN) signal and the relay enable (TR_EN) signal obtained by the repeater judgment part 1522 are at the high level, data is read from the buffer and transmitted.

[0114] FIG. 17 is a block diagram showing the configuration of an example of the base station according to the invention. The base station 406 is constructed by: a plurality of antennas 1701a, 1701b, and 1701c for transmitting/receiving RF signals in a radio area; a radio frequency part 1702 for performing a filtering process on signals received from the antennas 1701a, 1701b, and 1701c, an A/D converting process of converting an analog signal to a digital signal, a D/A converting process of converting a digital transmission signal to the antennas 1701a, 1701b, and 1701c to an analog signal, a filtering process, and power amplification; a modem part 1706 for restoring the transmission signal distributed to the plurality of antennas by the mobile station 408 from the signal received from the radio frequency part 1702, performing an error correcting process to obtain a reception signal, performing an encoding process of adding redundancy to the transmission signal to the radio frequency part 1702 so that error correction can be made, distributing the encoded signal to the plurality of antennas 1701a, 1701b, and 1701c, multiplexing a training signal on the signal so that the signal can be reconstructed by the mobile station 408, and generating a pilot signal necessary for the mobile station 408 and the repeater stations 407a, 407b, and 407c to generate a reference timing, a control part 1712 for extracting the control signal from the reception signal obtained from the modem part 1706, performing a protocol process related to call connection or relay operation, and controlling the transmitting/receiving timings at the time of relay; and an interface 1717 between stations, for passing the signal received from the control part 1712 to the control station 405, multiplexing a signal from the control station 405 and a signal generated from the base station 406, and passing the resultant signal to the modem part 1706. Detailed description will be made below in accordance with the flow of signals.

[0115] The radio signals received by the antennas 1701a, 1701b, and 1701c are sent to receivers 1704a, 1704b, and 1704c via circulators 1703a, 1703b, and 1703c of the radio frequency part 1702, respectively. The receivers 1704a, 1704b, and 1704c performs a filtering process on the reception signals so that the bandwidth is changed to a base band signal processing bandwidth, convert an analog signal to a digital signal (A/D conversion), and transmit the resultant to the modem part 1706. In the modem part 1706, the reception signal is separated by a demultiplexer 1707 for each mobile station and distributed to the receivers 102a and 102b. In the receivers 102a and 102b, the transmission signals distributed by the mobile station to the plurality of antennas are restored by the MIMO demodulators 1010a and 1010b, the restored transmission signals of the number of the plurality of antennas are converted to the encoded data by the P/S converters 1011a and 101b, and a decoding process for performing error correction on the encoded data is performed by error correction decoders 1709a and 1709b, thereby obtaining reception data. The reception data is passed to the control part 1712 and separated by a separator 1714 into a control signal and data of the user application. The control signal is dealt by a protocol processing part 1715 which performs a protocol processing for call connection or relay operation. The data of the control signal of relay operation directions issued for each user is held as relay operation directions parameters 1716a and 1716b. On the basis of timing parameters (DST, DLEN, UST, and ULEN) defined here, timing signals (relay mode: MODE, direct wave: DR_EN, and repeater station wave: RP_EN) necessary for the MIMO demodulators 1010a and 1010b and timing signals (transmission enable: TX_EN) necessary for the MIMO modulator 1013b are generated by calculation parts 1713a and 1713b of transmission/reception. Data of a plurality of user applications separated by the separator 1714 is multiplexed by a multiplexer 1720 in accordance with the interface 1717 between stations and the resultant data is transmitted to the control center 405. Data received from the control center 405 and a control signal generated by the protocol processing part 1715 are multiplexed by a multiplexer 1719, and distributed by demultiplexer 1718 to the transmitters 101a and 101b for each of the users.

[0116] In the transmitters 101a and 101b, the transmission data is converted by error correction encoders 1710a and 1710b to encoded data to which redundancy is added so that error correction can be made in the mobile station 408. The encoded data is serial-to-parallel converted by the S/P converters 1014a and 1014b, thereby distributing the resultant data as transmission signals to the plurality of antennas 1701a, 1701b, and 1701c of the base station 406. A training signal is added to the transmission signal by the MIMO

modulators **1013***a* and **1013***b* so that MIMO demodulation can be carried out by the mobile station **408**. Transmission data of the transmitters **101***a* and **101***b* and the pilot signal generated by a pilot signal generator **1711** are multiplexed by a multiplexer **1708**, and the transmission data is supplied to each of transmitters **1705***a*, **1705***b*, and **1705***c* of the radio frequency part **1702**.

[0117] In the transmitters **1705***a*, **1705***b*, and **1705***c*, the transmission data is A/D converted from a digital signal to an analog signal, a filtering process, and power amplification are performed, and the transmission data is transmitted as a radio signal from the antennas **1701***a*, **1701***b*, and **1701***c* via the circulators **1703***a*, **1703***b*, and **1703***c*. In the above description, the MIMO demodulators **1010***a* and **1010***b* of the receivers **102***a* and **102***b* have the same configuration as that described in **FIG. 12**, and the MIMO modulators **1013***a* and **1013***b* in the transmitters **101***a* and **101***b* have the same configuration as that described with reference to **FIG. 13**.

[0118] **FIGS. 18A and 18B** are timing charts for explaining the operation of the calculator part of transceiver timings in an example of the base station according to the invention. **FIG. 18A** shows operations in the state where repeaters do not act. The relay mode (MODE) becomes a fixed output at a low level indicative of the state where repeaters do not act. The direct wave (DR_EN) from the mobile station **408** becomes a low-level output in the interval of the pilot signal and becomes a high-level output in the interval of the mobile station signal. A wave (RP_EN) via the repeater station as an indirect wave from the repeater stations **407***a*, **407***b*, and **407***c* is an output fixed at the low-level. A transmission timing (TX_EN) of the base station **406** becomes a low-level output in the interval of the pilot signal, and a high-level output in the base station broadcast time.

[0119] **FIG. 18B** shows operations in the state where the repeaters act. The relay mode (MODE) becomes an output fixed at the high level indicative of relay. The direct wave (DR_EN) from the mobile station **408** is a high-level output from a timing deviated from the pilot signal as a reference by UST specified by the relay operation directions parameters **1716***a*, for the period of ULEN similarly specified by the relay operation directions parameters **1716***a*. The direct wave (DR_EN) becomes a low-level output for the period of the next ULEN. The direct wave alternately becomes the high level and low level until the interval of the next pilot signal. The wave (RP_EN) via the repeater station as an indirect wave from each of the repeater stations **407***a*, **407***b*, and **407***c* becomes a high-level output in the interval where the DR_EN is at the low level for the period of ULEN and becomes a low-level output in the other period. The transmission timing (TX_EN) of the base station **406** becomes a high-level output from a timing deviated from the pilot signal as a reference by DST specified by the relay operation directions parameters **1716***a*, for the period of DLEN similarly specified by the relay operation directions parameters **1716***a*. The transmission timing goes low for the period of the next DLEN and alternately becomes the high and low levels until the interval of the next pilot signal.

[0120] **FIG. 20** is a block diagram showing the configuration of another embodiment of the wireless transmission repeater system according to the invention. The embodiment obtains substantially the same effects as those of the foregoing embodiment by disposing a plurality of reflectors in specific positions in place of the plurality of repeaters **301** in the wireless transmission repeater system shown in **FIG. 3**. In the case where either the transmitter **101** or receiver **102** is fixedly mounted, reflectors **2001***a*, **2001***b*, and **2001***c* are disposed in an insight range in which the reflectors **2001***a*, **2001***b*, and **2001***c* can be directly seen from the fixedly mounted device. **FIG. 20** will be described on assumption that the transmitter **101** is fixedly mounted. Radio signals transmitted from the transmitter **101** are reflected by the reflectors **2001***a*, **2001***b*, and **2001***c* and reach the receiver **102**. By disposing the reflectors **2001***a*, **2001***b*, and **2001***c*, the multipath transmission environment can be artificially generated from the insight transmission environment, so that the communication path capacity can be increased by the MIMO process.

[0121] According to the invention, in the mobile communication system using a (MIMO) process of receiving radio signals transmitted from a transmitter so as to be distributed to a plurality of antennas by a receiver via a plurality of antennas and restoring the transmission signals distributed from the transmitter, even in an insight transmission environment in which the transmitter and receiver can see each other directly, by introducing repeaters, a plurality of propagation paths are provided, thereby artificially generating the multipath transmission environment. With the configuration, an effect can be obtained such that the characteristic of the communication path capacity is improved as compared with the insight transmission environment in which repeaters are not introduced.

[0122] **FIG. 19** shows the result of comparison between the characteristic of the case where the invention is used (with repeaters) and that of the case where the invention is not applied (without repeaters). The lateral axis denotes the number of antennas of a transmitter and a receiver, and the vertical axis indicates the communication path capacity. It is assumed that the number of antennas of the transmitter and that of the receiver are the same and the number of repeater stations is five times as many as the number of reception antennas, evaluation was made in the environment where the signal-to-noise (S/N) ratio of the propagation path is 30 dB. It is understood from **FIG. 19** that when the number of antennas of the transmitter and receiver is four or more, the transmission repeater system using the invention has the better characteristic of the communication path capacity.

[0123] While the present invention has been described above in conjunction with the preferred embodiments, one of skill in the art would be enabled by this disclosure to make various modifications to the embodiments and still be within the scope and spirit of the invention as defined in the appended claims.

What is claimed is:

1. A wireless transmission repeater system comprising:

a first wireless device having a transmitter for distributing transmission data including encoded data and a training signal to a plurality of antennas, and transmitting the data as radio signals from said plurality of antennas at a predetermined timing;

a plurality of second wireless devices having repeaters each for receiving said radio signal, storing said radio

signal into a buffer so that said radio signal is delayed by predetermined time, and transmitting said radio signal delayed; and

a third wireless device having a receiver for receiving the radio signals from said plurality of second wireless devices by a plurality of antennas and demodulating said encoded data by using said training signal multiplexed on the received radio signal.

2. A wireless transmission repeater system comprising:

a first wireless device having a transmitter including means for distributing encoded data to a plurality of antennas, means for multiplexing a training signal for restoring the distributed data on a reception side onto said data, and means for controlling a transmission timing, the transmitter for transmitting radio signals from the plurality of antennas;

a second wireless device having a repeater including means for receiving the signal transmitted from said first wireless device and storing the signal into a buffer, and means for delaying the stored signal by predetermined time to thereby control a timing of transmitting the signal; and

a third wireless device having a receiver including means for controlling a reception timing to receive the radio signals transmitted from said second wireless device by a plurality of antennas, means for restoring the data distributed from the transmitter of said first wireless device to the plurality of antennas by using said training signal multiplexed on the received radio signal, and means for parallel-to-serial converting the data distributed to the plurality of antennas to combine the distributed data into encoded data, thereby obtaining reception data.

3. The wireless transmission repeater system according to claim 2, wherein the encoding means of said first wireless device has encoding means for adding redundancy to said encoded data so that error in the data is corrected, and the receiver of said third wireless device has means for performing an error correction decoding process on said encoded data by using said redundancy.

4. The wireless transmission repeater system according to claim 2, wherein said first, second, and third wireless devices are a base station, a repeater station, and a mobile station, respectively,

said mobile station measures a reception power of a pilot signal periodically transmitted from said base station, when the reception power of said pilot signal is equal to or higher than a threshold value, notifies said base station of a demand to start relaying by the repeater station, and when the reception power of said pilot signal is lower than the threshold value, notifies said base station of a demand to stop relaying by the repeater station,

when said relay start demand is received, said base station instructs said repeater station to start the relaying operation, and when said relay stop demand is received, said base station instructs said repeater station to stop the relaying operation.

5. The wireless transmission repeater system according to claim 2, wherein said first, second, and third wireless devices are a base station, a repeater station, and a mobile station, respectively,

said mobile station measures a signal-to-noise ratio of a pilot signal periodically transmitted from said base station, when the signal-to-noise ratio of said pilot signal is equal to or higher than a threshold value, notifies said base station of a demand to start relaying, by the repeater station, and when the signal-to-noise ratio of said pilot signal is lower than the threshold value, notifies said base station of a demand to stop relaying by the repeater station,

when said relay start demand is received, said base station instructs said repeater station to start the relaying operation, and when said relay stop demand is received, said base station instructs said repeater station to stop the relaying operation.

6. The wireless transmission repeater system according to claim 2, wherein said first, second, and third wireless devices are a base station, a repeater station, and a mobile station, respectively,

said mobile station measures a signal-to-noise ratio of a pilot signal periodically transmitted from said base station, presumes a propagation path by using said training signal, calculates a communication capacity from said signal-to-noise ratio and the result of said propagation path estimation, when said communication capacity is equal to or lower than a threshold value, notifies said base station of a demand to start relaying by the repeater station, when said communication capacity is higher than the threshold, notifies said base station of a demand to stop the relaying by the repeater station,

when said relay start demand is received, said base station instructs said repeater station to start the relaying operation, and when the relay stop demand is received, said base station instructs said repeater station to stop the relaying operation.

7. The wireless transmission repeater system according to claim 2, wherein the base station notifies the repeater station and the mobile station of an offset of each of a transmission timing of the transmitter, a reception timing and a transmission timing of the repeater, and a reception timing of the receiver with respect to the pilot signal as a reference which is periodically transmitted from said base station by using a control signal, to thereby determine operation timings at the time of relaying operation.

8. The wireless transmission repeater system according to claim 1, wherein either said first or second wireless device is fixedly mounted in a position, and a reflector for reflecting the radio signal in place of said second wireless device is disposed in an insight range in which the reflector can be directly seen by said fixedly disposed wireless device.

9. The wireless transmission repeater system according to claim 2, wherein either said first or second wireless device is fixedly mounted in a position, and a reflector for reflecting the radio signal in place of said second wireless device is disposed in an insight range in which the reflector can be directly seen by said fixedly disposed wireless device.

10. A mobile station for use in a wireless transmission repeater system for performing wireless communication in an MIMO communication system in which a plurality of repeater stations are disposed between a mobile station and a base station, comprising:

a separator for separating a control signal and transmission data from said base station from a reception signal;

a receiver for restoring the separated transmission data;

a repeater judgment part for judging whether relaying operation by said plurality of repeater stations is necessary or not on the basis of the control signal from said reception signal;

a transmitter for generating data to be transmitted and transmitting the data; and

a control part for controlling said receiver and transmitter by using said control signal, generating a control signal of a relay start demand or a relay stop demand to said base station in accordance with a result of judgment of said relay judgment part, and adding the control signal of said relay start demand or relay stop demand to said data to be transmitted.

11. A base station for use in a wireless transmission repeater system for performing wireless communication in accordance with an MIMO communication system, in which a plurality of repeater stations are disposed between a mobile station and a base station, comprising:

a separator for separating a control signal and transmission data from said base station from a reception signal;

a receiver for restoring the separated transmission data;

a repeater judgment part for judging whether relaying operation by said plurality of repeater stations is necessary or not on the basis of the control signal from said reception signal;

a transmitter for generating data to be transmitted and transmitting the data; and

a control part for controlling said receiver and transmitter by using said control signal, generating a control signal of a relay operation instruction to said base station and repeater station in accordance with a result of judgment of said relay judgment part, and adding the control signal of said operation instruction to said data to be transmitted.

12. A repeater station for use in a wireless transmission repeater system for performing wireless communication in accordance with an MIMO communication system, in which a plurality of repeater stations are disposed between a mobile station and a base station, comprising:

a separator for separating a control signal and transmission data from said mobile station or base station from a reception signal;

a repeater for buffering the separated transmission data;

a repeater judgment part for judging whether relaying operation is necessary or not by measuring a power of a base station pilot signal included in said control signal or said transmission data;

a calculation part for obtaining a transmission timing by using said base station pilot signal; and

a transmitter for transmitting transmission data of said repeater at said transmission timing.

13. The repeater station according to claim 11, further comprising a transmission/reception part for performing a wireless communication which is not according to the MIMO communication system.

* * * * *